OMB Number: 2030-0020
Expiration Date: 06/30/2024

Preaward Compliance Review Report for All Applicants and Recipients Requesting EPA Financial Assistance

Note: Read Instructions before completing form.

I. A. Applicant/Recipient (Name, Address, City, State, Zip Code)

Name: Eun-Hye Yoo

Address: The UB Commons, 52 Lee Entrance, Suite 211, Amherst, Erie, NY, USA
~~University at Buffalo, SUNY~~

City: Buffalo

State: NY: New York Zip Code: 14261

B. DUNS No. 0386332510000

II. Is the applicant currently receiving EPA Assistance? ☐ Yes ☒ No

III. List all civil rights lawsuits and administrative complaints pending against the applicant/recipient that allege discrimination based on race, color, national origin, sex, age, or disability. (Do not include employment complaints not covered by 40 C.F.R. Parts 5 and 7.)

IV. List all civil rights lawsuits and administrative complaints decided against the applicant/recipient within the last year that allege discrimination based on race, color, national origin, sex, age, or disability and enclose a copy of all decisions. Please describe all corrective actions taken. (Do not include employment complaints not covered by 40 C.F.R. Parts 5 and 7.)

V. List all civil rights compliance reviews of the applicant/recipient conducted by any agency within the last two years and enclose a copy of the review and any decisions, orders, or agreements based on the review. Please describe any corrective action taken. (40 C.F.R. § 7.80(c)(3))

VI. Is the applicant requesting EPA assistance for new construction? If no, proceed to VII; if yes, answer (a) and/or (b) below.

☐ Yes ☒ No

a. If the grant is for new construction, will all new facilities or alterations to existing facilities be designed and constructed to be readily accessible to and usable by persons with disabilities? If yes, proceed to VII; if no, proceed to VI(b).

☐ Yes ☐ No

b. If the grant is for new construction and the new facilities or alterations to existing facilities will not be readily accessible to and usable by persons with disabilities, explain how a regulatory exception (40 C.F.R. 7.70) applies.

VII. Does the applicant/recipient provide initial and continuing notice that it does not discriminate on the basis of race, color, national origin, sex, age, or disability in its program or activities? (40 C.F.R 5.140 and 7.95)	☒ Yes	☐ No
a. Do the methods of notice accommodate those with impaired vision or hearing?	☒ Yes	☐ No
b. Is the notice posted in a prominent place in the applicant's offices or facilities or, for education programs and activities, in appropriate periodicals and other written communications?	☒ Yes	☐ No
c. Does the notice identify a designated civil rights coordinator?	☐ Yes	☒ No
VIII. Does the applicant/recipient maintain demographic data on the race, color, national origin, sex, age, or handicap of the population it serves? (40 C.F.R. 7.85(a))	☒ Yes	☐ No
IX. Does the applicant/recipient have a policy/procedure for providing access to services for persons with limited English proficiency? (40 C.F.R. Part 7, E.O. 13166)	☒ Yes	☐ No

X. If the applicant is an education program or activity, or has 15 or more employees, has it designated an employee to coordinate its compliance with 40 C.F.R. Parts 5 and 7? Provide the name, title, position, mailing address, e-mail address, fax number, and telephone number of the designated coordinator.

XI. If the applicant is an education program or activity, or has 15 or more employees, has it adopted grievance procedures that assure the prompt and fair resolution of complaints that allege a violation of 40 C.F.R. Parts 5 and 7? Provide a legal citation or Internet Address for, or a copy of, the procedures.

For the Applicant/Recipient

I certify that the statements I have made on this form and all attachments thereto are true, accurate and complete. I acknowledge that any knowingly false or misleading statement may be punishable by fine or imprisonment or both under applicable law. I assure that I will fully comply with all applicable civil rights statutes and EPA regulations.

A. Signature of Authorized Official	B. Title of Authorized Official	C. Date
Amy M Lagowski	Sponsored Project Associate	03/25/2022

For the U.S. Environmental Protection Agency

I have reviewed the information provided by the applicant/recipient and hereby certify that the applicant/recipient has submitted all preaward compliance information required by 40 C.F.R. Parts 5 and 7; that based on the information submitted, this application satisfies the preaward provisions of 40 C.F.R. Parts 5 and 7; and that the applicant has given assurance that it will fully comply with all applicable civil rights statures and EPA regulations.

A. *Signature of Authorized EPA Official	B. Title of Authorized Official	C. Date

*** See Instructions**

Instructions for EPA FORM 4700-4 (Rev. 06/2014)

General. Recipients of Federal financial assistance from the U.S. Environmental Protection Agency must comply with the following statutes and regulations.
Title VI of the Civil Rights Acts of 1964 provides that no person in the United States shall, on the grounds of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance. The Act goes on to explain that the statute shall not be construed to authorize action with respect to any employment practice of any employer, employment agency, or labor organization (except where the primary objective of the Federal financial assistance is to provide employment). Section 13 of the 1972 Amendments to the Federal Water Pollution Control Act provides that no person in the United States shall on the ground of sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under the Federal Water Pollution Control Act, as amended. Employment discrimination on the basis of sex is prohibited in all such programs or activities. Section 504 of the Rehabilitation Act of 1973 provides that no otherwise qualified individual with a disability in the United States shall solely by reason of disability be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance. Employment discrimination on the basis of disability is prohibited in all such programs or activities. The Age Discrimination Act of 1975 provides that no person on the basis of age shall be excluded from participation under any program or activity receiving Federal financial assistance. Employment discrimination is not covered. Age discrimination in employment is prohibited by the Age Discrimination in Employment Act administered by the Equal Employment Opportunity Commission. Title IX of the Education Amendments of 1972 provides that no person in the United States on the basis of sex shall be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any education program or activity receiving Federal financial assistance. Employment discrimination on the basis of sex is prohibited in all such education programs or activities. Note: an education program or activity is not limited to only those conducted by a formal institution. 40 C.F.R. Part 5 implements Title IX of the Education Amendments of 1972. 40 C.F.R. Part 7 implements Title VI of the Civil Rights Act of 1964, Section 13 of the 1972 Amendments to the Federal Water Pollution Control Act, and Section 504 of The Rehabilitation Act of 1973. The Executive Order 13166 (E.O. 13166) entitled; "Improving Access to Services for Persons with Limited English Proficiency" requires Federal agencies work to ensure that recipients of Federal financial assistance provide meaningful access to their LEP applicants and beneficiaries.

Items "Applicant" means any entity that files an application or unsolicited proposal or otherwise requests EPA assistance. 40 C.F.R. §§ 5.105, 7.25. "Recipient" means any entity, other than applicant, which will actually receive EPA assistance. 40 C.F.R. §§ 5.105, 7.25. "Civil rights lawsuits and administrative complaints" means any lawsuit or administrative complaint alleging discrimination on the basis of race, color, national origin, sex, age, or disability pending or decided against the applicant and/or entity which actually benefits from the grant, but excluding employment complaints not covered by 40 C.F.R. Parts 5 and 7. For example, if a city is the named applicant but the grant will actually benefit the Department of Sewage, civil rights lawsuits involving both the city and the Department of Sewage should be listed. "Civil rights compliance review" means any review assessing the applicant's and/or recipient's compliance with laws prohibiting discrimination on the basis of race, color, national origin, sex, age, or disability. Submit this form with the original and required copies of applications, requests for extensions, requests for increase of funds, etc. Updates of information are all that are required after the initial application submission. If any item is not relevant to the project for which assistance is requested, write "NA" for "Not Applicable." In the event applicant is uncertain about how to answer any questions, EPA program officials should be contacted for clarification. * Note: Signature appears in the Approval Section of the EPA Comprehensive Administrative Review For Grants/Cooperative Agreements & Continuation/Supplemental Awards form.

EPA KEY CONTACTS FORM

OMB Number: 2030-0020
Expiration Date: 06/30/2024

Authorized Representative: *Original awards and amendments will be sent to this individual for review and acceptance, unless otherwise indicated.*

Name: Prefix: | First Name: Amy | Middle Name:
Last Name: Lagowski | Suffix:
Title: Sponsored Projects Associate

Complete Address:

Street1: The UB Commons
Street2: 52 Lee Entrance, Suite 211
City: Amherst | State: NY: New York
Zip / Postal Code: 14228-2567 | Country: USA: UNITED STATES
Phone Number: 716-645-4419 | **Fax Number:**
E-mail Address: Amy.Lagowski@buffalo.edu

Payee: *Individual authorized to accept payments.*

Name: Prefix: | First Name: Maryssa | Middle Name:
Last Name: McDaniel | Suffix:
Title: Accounts Receivable/Financial Reporting Coord

Complete Address:

Street1: The UB Commons
Street2: 52 Lee Entrance, Suite 211
City: Amherst | State: NY: New York
Zip / Postal Code: 14228-2567 | Country: USA: UNITED STATES
Phone Number: 716-645-4382 | **Fax Number:**
E-mail Address: Maryssa.Kunes@buffalo.edu

Administrative Contact: *Individual from Sponsored Programs Office to contact concerning administrative matters (i.e., indirect cost rate computation, rebudgeting requests etc).*

Name: Prefix: | First Name: Amy | Middle Name:
Last Name: Lagowski | Suffix:
Title: Sponsored Projects Associate

Complete Address:

Street1: The UB Commons
Street2: 52 Lee Entrance, Suite 211
City: Amherst | State: NY: New York
Zip / Postal Code: 14228-2567 | Country: USA: UNITED STATES
Phone Number: 716-645-4419 | **Fax Number:**
E-mail Address: Amy.Lagowski@buffalo.edu

EPA Form 5700-54 (Rev 4-02)

EPA KEY CONTACTS FORM

Project Manager: *Individual responsible for the technical completion of the proposed work.*

Name: **Prefix:** Dr. **First Name:** Eun-Hye **Middle Name:**

Last Name: Yoo **Suffix:**

Title: Associate Professor

Complete Address:

Street1: The UB Commons

Street2: 520 Lee Entrance, Suite 211

City: Amherst **State:** NY: New York

Zip / Postal Code: 14228-2567 **Country:** USA: UNITED STATES

Phone Number: 716-645-0476 **Fax Number:**

E-mail Address:

EPA Form 5700-54 (Rev 4-02)

Other Attachment File(s)

*** Mandatory Other Attachment Filename:** 1234-QAS 0322.pdf

Add Mandatory Other Attachment | Delete Mandatory Other Attachment | View Mandatory Other Attachment

To add more "Other Attachment" attachments, please use the attachment buttons below.

Add Optional Other Attachment | Delete Optional Other Attachment | View Optional Other Attachment

Project Narrative File(s)

*** Mandatory Project Narrative File Filename:** 1237- project narrative 0322.pdf

Add Mandatory Project Narrative File | Delete Mandatory Project Narrative File | View Mandatory Project Narrative File

To add more Project Narrative File attachments, please use the attachment buttons below.

Add Optional Project Narrative File | Delete Optional Project Narrative File | View Optional Project Narrative File

BUDGET INFORMATION - Non-Construction Programs

OMB Number: 4040-0006
Expiration Date: 02/28/2022

SECTION A - BUDGET SUMMARY

Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds		New or Revised Budget		
		Federal (c)	Non-Federal (d)	Federal (e)	Non-Federal (f)	Total (g)
1. N/A	66.034	$	$	$ 499,963.00	$	$ 499,963.00
2.						
3.						
4.						
5. Totals		$	$	$ 499,963.00	$	$ 499,963.00

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SECTION B - BUDGET CATEGORIES

6. Object Class Categories	GRANT PROGRAM, FUNCTION OR ACTIVITY (1)	(2)	(3)	(4)	Total (5)
	N/A				
a. Personnel	$ 179,182.00	$	$	$	$ 179,182.00
b. Fringe Benefits	48,622.00				48,622.00
c. Travel	13,724.00				13,724.00
d. Equipment					
e. Supplies	21,039.00				21,039.00
f. Contractual					
g. Construction					
h. Other	64,212.00				64,212.00
i. Total Direct Charges (sum of 6a-6h)	326,779.00				$ 326,779.00
j. Indirect Charges	173,184.00				$ 173,184.00
k. TOTALS (sum of 6i and 6j)	$ 499,963.00	$	$	$	$ 499,963.00
7. Program Income	$	$	$	$	$

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SECTION C - NON-FEDERAL RESOURCES

(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e)TOTALS
8.	$	$	$	$
9.				
10.				
11.				
12. TOTAL (sum of lines 8-11)	$	$	$	$

SECTION D - FORECASTED CASH NEEDS

	Total for 1st Year	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
13. Federal	$ 189,636.00	$ 47,409.00	$ 47,409.00	$ 47,409.00	$ 47,409.00
14. Non-Federal	$				
15. TOTAL (sum of lines 13 and 14)	$ 189,636.00	$ 47,409.00	$ 47,409.00	$ 47,409.00	$ 47,409.00

SECTION E - BUDGET ESTIMATES OF FEDERAL FUNDS NEEDED FOR BALANCE OF THE PROJECT

(a) Grant Program	FUTURE FUNDING PERIODS (YEARS) (b)First	(c) Second	(d) Third	(e) Fourth
16. N/A	$ 170,114.00	$ 140,213.00	$	$
17.				
18.				
19.				
20. TOTAL (sum of lines 16 - 19)	$ 170,114.00	$ 140,213.00	$	$

SECTION F - OTHER BUDGET INFORMATION

21. Direct Charges: 326779

22. Indirect Charges: 173184

23. Remarks: Total Budget costs for the project are $499,963 and are using UB's federally negotiated indirect cost base (MTDC; 59.5%)

OMB Number: 4040-0004
Expiration Date: 12/31/2022

Application for Federal Assistance SF-424

* 1. Type of Submission:
- [ ] Preapplication
- [x] Application
- [ ] Changed/Corrected Application

* 2. Type of Application:
- [x] New
- [ ] Continuation
- [ ] Revision

* If Revision, select appropriate letter(s):

* Other (Specify):

* 3. Date Received: 03/25/2022

4. Applicant Identifier:

5a. Federal Entity Identifier:

5b. Federal Award Identifier:

State Use Only:

6. Date Received by State:

7. State Application Identifier:

8. APPLICANT INFORMATION:

* a. Legal Name: The Research Foundation for SUNY on behalf of U. at Buffalo

* b. Employer/Taxpayer Identification Number (EIN/TIN): 14-1368361

* c. Organizational DUNS: 0386332510000

d. Address:

* Street1: The UB Commons
Street2: 520 Lee Entrance, Suite 211
* City: Amherst
County/Parish: Erie
* State: NY: New York
Province:
* Country: USA: UNITED STATES
* Zip / Postal Code: 14228-2567

e. Organizational Unit:

Department Name: Sponsored Project Services

Division Name:

f. Name and contact information of person to be contacted on matters involving this application:

Prefix:
* First Name: Eun-Hye
Middle Name:
* Last Name: Yoo
Suffix:

Title: Associate Professor

Organizational Affiliation:

* Telephone Number: 716-645-0476
Fax Number:

* Email: eunhye@buffalo.edu

Application for Federal Assistance SF-424

*** 9. Type of Applicant 1: Select Applicant Type:**

X: Other (specify)

Type of Applicant 2: Select Applicant Type:

Type of Applicant 3: Select Applicant Type:

* Other (specify):

Private; Non-Profit

*** 10. Name of Federal Agency:**

Environmental Protection Agency

11. Catalog of Federal Domestic Assistance Number:

66.034

CFDA Title:

Surveys, Studies, Research, Investigations, Demonstrations, and Special Purpose Activities Relating to the Clean Air Act

*** 12. Funding Opportunity Number:**

EPA-OAR-OAQPS-22-01

* Title:

Enhanced Air Quality Monitoring for Communities

13. Competition Identification Number:

Title:

14. Areas Affected by Project (Cities, Counties, States, etc.):

Add Attachment | Delete Attachment | View Attachment

*** 15. Descriptive Title of Applicant's Project:**

Improving air quality monitoring for Buffalo African-American community

Attach supporting documents as specified in agency instructions.

Add Attachments | Delete Attachments | View Attachments

Application for Federal Assistance SF-424

16. Congressional Districts Of:

* a. Applicant: NY-026 * b. Program/Project: NY-026

Attach an additional list of Program/Project Congressional Districts if needed.

Add Attachment | Delete Attachment | View Attachment

17. Proposed Project:

* a. Start Date: 11/01/2022 * b. End Date: 10/31/2025

18. Estimated Funding ($):

* a. Federal	499,963.00
* b. Applicant	0.00
* c. State	0.00
* d. Local	0.00
* e. Other	0.00
* f. Program Income	0.00
* g. TOTAL	499,963.00

*** 19. Is Application Subject to Review By State Under Executive Order 12372 Process?**

☐ a. This application was made available to the State under the Executive Order 12372 Process for review on .

☐ b. Program is subject to E.O. 12372 but has not been selected by the State for review.

☒ c. Program is not covered by E.O. 12372.

*** 20. Is the Applicant Delinquent On Any Federal Debt? (If "Yes," provide explanation in attachment.)**

☐ Yes ☒ No

If "Yes", provide explanation and attach

Add Attachment | Delete Attachment | View Attachment

21. *By signing this application, I certify (1) to the statements contained in the list of certifications and (2) that the statements herein are true, complete and accurate to the best of my knowledge. I also provide the required assurances** and agree to comply with any resulting terms if I accept an award. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. (U.S. Code, Title 218, Section 1001)**

☒ ** I AGREE

** The list of certifications and assurances, or an internet site where you may obtain this list, is contained in the announcement or agency specific instructions.

Authorized Representative:

Prefix: * First Name: Amy

Middle Name:

* Last Name: Lagowski

Suffix:

* Title: Sponsored Project Associate

* Telephone Number: 716-645-4419 Fax Number: 716-645-2760

* Email: Amy.Lagowski@buffalo.edu

* Signature of Authorized Representative: Amy M Lagowski * Date Signed: 03/25/2022

Buffalo Center for Health Equity

03/07/2022

Eun-Hye (Enki) Yoo
Associate Professor
Department of Geography
University at Buffalo
121 Wilkeson Quad
Buffalo, NY 14261-0055

Dear Enki:

I am delighted to support your EPA-ORA-OAQPS-22-01 grant application titled, "Improving air quality monitoring for the Buffalo African-American community".

I believe that the proposed project will make an important contribution addressing health inequality among the Buffalo African-American community based on race, economics, geography, and environment. More specifically, it will document and quantify the extent of health disparities in Buffalo's African-American community that are associated with disparities in air pollution exposure. The proposed project will increase the awareness of air pollution exposure as a serious risk factor for respiratory diseases among the members of this community, create a space for community conversations around environmental justice, and most importantly it will provide concrete data on air pollution and its disparate health impact and inform the community on measures to mitigate health effect and to support air pollution informed policy development.

As you know, I am the convener of the African American Health Equity Task Force, co-founder of the Buffalo Community Center for Health Equity, and the Greater Buffalo Racial Equity Roundtable. In past years, I also have organized and led multiple work forces, and convened conferences and meetings with academics, grassroot organizers, church leaders, and community members. In our previous investigations, we found that infant mortality rates among African-Americans concentrated in my neighborhoods were almost three times higher than that of Whites, while rates of children's asthma hospitalization were four times higher. In summary, I believe that your proposed research has significant implications in addressing health disparities in my community.

As a consultant of this project, I will take a leadership role in encouraging my community members to participate in the proposed research activities, assist in the development of interviews/surveys, facilitate the installation of outdoor sensors in the community, and provide feedback to the research team about any concerns or issues that arise in the community. In addition, I will participate in communicating research findings to the community to help minimize risk of harmful environmental exposures and reduce health disparities in this region.

I look forward to working with you on this proposal.

Sincerely,

George F. Nicholas

Eun-Hye Enki Yoo

Department of Geography
University at Buffalo, the State University of New York
121 Wilkeson Quad, Buffalo, NY, 14261-0055

Tel: (716) 645-0476
Fax: (716) 645-2329
Email: eunhye@buffalo.edu

EDUCATION

Seoul National University, Korea	Geography	BA/1997
Seoul National University, Korea	Geography	MA/1999
University of California Santa Barbara, CA	Geography	PhD/2006

ACADEMIC APPOINTMENT

2014-Present	Associate Professor, Department of Geography, University at Buffalo, The State University of New York, USA
2008-Present	Member of National Center for Geographic Information and Analysis (NCGIA), University at Buffalo, The State University of New York, USA
2007-2014	Assistant Professor, Department of Geography, University at Buffalo, The State University of New York, USA

SELECTED GRANTS

R01 GM108731, Bian (PI), Role: Co-Investigator, 03/10/2015-02/28/2022
"*A three-population three-scale social network model to assess disease dispersion*", Research on cell phone data mining to construct a census social network and the disease transmission simulation through the network.

Research and Education in Energy, Environment and Water (RENEW) Standard Seed Grants, University at Buffalo, SUNY, Yoo (PI), Role: Principal Investigator, Jan. 15, 2017 – Jan. 15, 2019
"*Modeling ambient air pollution using optimal sensor placement and multiscale spatiotemporal data fusion*"
Research on a supplementary data collection strategy and a data fusion framework to predict air quality needed in a given epidemiological and regulatory context using recent technological advancements in sensor developments and sensor network design.

PERSONAL STATEMENT

Eun-Hye Yoo is a Geographer with independent research experience in the development of geostatistical fusion methods, spatial uncertainty analysis, and most recently environmental exposure and health impact assessment. She has extensive experience in using geographic information science (GIS), Global Positioning System (GPS), remote sensing (RS) and spatial statistics to solve various problems in public health and environmental science. She has more than 63 publications to date, many of which were published in to-tier journals on GIScience, Environmental Science, and Environmental Epidemiology. In recent studies, she examined the association between emergency room (ER) visits for mental disorders and extreme temperature, air pollution, and greenspace using spatially and temporally resolved environmental exposure estimates obtained from multi-sourced, incompatible, and massive geospatial data. In her previous work she utilized geostatistical data fusion methods to integrate both satellite-derived aerosol optical depth (AOD) and community multiscale air quality model (CMAQ) simulations, and further combined them with individuals' fine-grained time-location data collected from GPS-enabled mobile phones for personal air pollution exposure assessment (R21; ES017826). In addition, she led a team to determine how to deploy low-cost portable air pollution sensors and calibrate measurements to assess acute air pollution exposures (the University at Buffalo, SUNY RENEW Standard Seed Grants).

PEER-REVIEWED JOURNAL ARTICLES

Complete List of Published Work in Google Scholar:
https://scholar.google.com/citations?user=eDHJqA8AAAAJ&hl=en&oi=sra

Selected Publications († denotes the graduate student)

1. **Yoo E.-H.**, Roberts J.E., †Eum Y., Li X., †L. Chu, P. Wang, and K. Chen, 2022, Short-term exposure to fine particulate matter air pollution and mental disorders: A case-crossover study in New York City Environ Res.: Health (in press)
2. **Yoo E.-H.**, Roberts JE, Eum Y, Li X, Konty K. Exposure to urban green space may both promote and harm mental health in socially vulnerable neighborhoods: A neighborhood-scale analysis in New York City. Environ Res. 2022 Mar;204(Pt C):112292. PMID: 34728238.
3. **Yoo E.-H.**, Eum Y, Roberts JE, Gao Q, Chen K. Association between extreme temperatures and emergency room visits related to mental disorders: A multi-region time-series study in New York, USA. Sci Total Environ. 2021 Oct 20;792:148246. PMID: 34144243.
4. **Yoo E.-H.**, Eum Y, Gao Q, Chen K. Effect of extreme temperatures on daily emergency room visits for mental disorders. Environ Sci Pollut Res Int. 2021 Aug;28(29):39243-39256. PMID: 33751353.
5. Pu Q, **Yoo E.-H.** Ground $PM_{2.5}$ prediction using imputed MAIAC AOD with uncertainty quantification. Environ Pollut. 2021 Apr 1;274:116574. PMID: 33529896.
6. **Yoo E.-H.**, Pu Q, Eum Y, Jiang X. The Impact of Individual Mobility on Long-Term Exposure to Ambient PM2.5: Assessing Effect Modification by Travel Patterns and Spatial Variability of PM2.5. Int J Environ Res Public Health. 2021 Feb 23;18(4):2194. PMCID: PMC7926665.
7. **Yoo E.-H.**, Mangoin AZ, Chipeta M. Adaptive spatial sampling design for environmental field prediction using low-cost sensing technologies, Atmospheric Environ. 2020 221(15), 117091
8. Q Pu, **Yoo E.-H.** Spatio-temporal modeling of PM2.5 concentrations with missing data problem: a case study in Beijing, China, International Journal of Geographical Information Science, 2019 1-25.
9. Jiang X, **Yoo E.-H.** Modeling wildland fire-specific $PM_{2.5}$ concentrations for uncertainty-aware health impact assessments. Environ Sci Technol. 2019 Oct 15;53(20):11828-11839. PMID: 31533425.
10. Eum Y, **Yoo E.-H.**, Bowen E. Socioeconomic determinants of pediatric asthma emergency department visits under regional economic development in western New York. Soc Sci Med. 2019 Feb;222:133-144. PMID: 30640031.
11. **Yoo E.-H.**, Brown P, Eum Y. Ambient air quality and spatio-temporal patterns of cardiovascular emergency department visits. Int J Health Geogr. 2018 Jun 8;17(1):18. PMCID: PMC5994043
12. Mennis J. and **Yoo E.-H.**, 2018, Geographic Information Science and the analysis of place and health, Transaction in GIS, 22(3), pp.842-854.
13. Glasgow ML, Rudra CB, **E.-H.**, Demirbas M, Merriman J, Nayak P, Crabtree-Ide C, Szpiro AA, Rudra A, Wactawski-Wende J, Mu L. Using smartphones to collect time-activity data for long-term personal-level air pollution exposure assessment. J Expo Sci Environ Epidemiol. 2016 Jun;26(4):356-64. PMID: 25425137.
14. **Yoo E.-H.**, Rudra CB, Glasgow M, & Mu L. Geospatial estimation of individual exposure to air pollutants: moving from static monitoring to activity-based dynamic exposure assessment, Annals of the Association of American Geographers, 2015 105(5), 915-926.
15. Patterson K. and Yoo **E.-H.**, 2012, Trapped in poor places?: an assessment of the residential spatial patterns of housing choice voucher holders in 2004 and 2008, J Soc Ser Res., 38(5), 637-655.

Biographical Sketch

Dr. Kang Sun

Department of Civil, Structural & Environmental Engineering and RENEW Institute, University at Buffalo
E-mail: kangsun@buffalo.edu, Tel: (716)-645-6167

(a) Professional Preparation

Peking University	Beijing, China	Environmental Sciences	B.S., 2009
Princeton University	Princeton, NJ	Environmental Engineering	Ph.D., 2015
Harvard-Smithsonian Center for Astrophysics	Cambridge, MA	Atmospheric Chemistry	Postdoc Fellow, 2015–2017

(b) Appointments

2020–present: **Assistant Professor**, University at Buffalo, Buffalo, NY

2018–2020: **Research Assistant Professor**, University at Buffalo, Buffalo, NY

2017–2018: **Atmospheric Physicist**, Harvard-Smithsonian Center for Astrophysics, Cambridge, MA

2015–2017: **Postdoctoral Fellow**, Harvard-Smithsonian Center for Astrophysics, Cambridge, MA

2013: **Research Intern**, NEC Labs America, Princeton, NJ

2009–2015: **Research Assistant**, Princeton University, Princeton, NJ

(c) Products

1. C. Huang, **K. Sun**, J. Hu, T. Xue, H. Xu, and M. Wang, Estimating 2013–2019 NO_2 exposure with high spatiotemporal resolution in China using an ensemble model, ***Environmental Pollution***, 292, 118285, doi:10.1016/j.envpol.2021.118285, 2022.
2. **K. Sun**, L. Li, S. Jagini, and D. Li, A Satellite Data-Driven Framework to Rapidly Quantify Air Basin-Scale NO_x Emission and Its Application to the Po Valley during the COVID-19 Pandemic, ***Atmospheric Chemistry and Physics***, 21, 13311–13332, doi:10.5194/acp-21-13311-2021, 2021.
3. C. Staebell, **K. Sun**, J. Samra, J. Franklin, C. C. Miller, L. Xiong, E. Conway, K. Chance, and S. Wofsy, Spectral calibration of the MethaneAIR instrument, ***Atmospheric Measurement Techniques Discussion***, doi:10.5194/amt-2020-513.
4. M. A. G. Demetillo, C. Harkins, B. C. McDonald, P. S. Chodrow, **K. Sun**, and S. E. Pusede, Space-Based Observational Constraints on NO_2 Air Pollution Inequality From Diesel Traffic in Major US Cities, ***Geophysical Research Letters***, 48(17), e2021GL094333, doi:10.1029/2021GL094333, 2021.
5. Y. Zhang, **K. Sun**, Z. Gao, Z. Pan, M. Shook, and D. Li, Diurnal climatology of planetary boundary layer height over the contiguous United States derived from AMDAR and reanalysis data, ***Journal of Geophysical Research-Atmospheres***, doi:10.1029/2020JD032803.
6. M. A. G Demetillo, A. Navarro, K. K. Knowles, K. P. Fields, J. A. Geddes, C. R. Nowlan, S. J. Janz, L. M. Judd, J. Al-Saadi, **K. Sun**, B. C. McDonald, G. S. Diskin, and S. E. Pusede, Observing Nitrogen Dioxide Air Pollution Inequality Using High-Spatial-Resolution Remote Sensing Measurements in Houston, Texas, ***Environmental Science & Technology***, doi:10.1021/acs.est.0c01864, 2020.

7. G. Huang and **K. Sun**, Non-negligible impacts of clean air regulations on the reduction of tropospheric NO_2 over East China during the COVID-19 pandemic observed by OMI and TROPOMI, ***Science of The Total Environment***, 745, 141023, doi:10.1016/j.scitotenv.2020.141023, 2020.

8. **K. Sun**, L. Zhu, K. Cady-Pereira, C. Chan Miller, K. Chance, L. Clarisse, P.-F. Coheur, G. González Abad, G. Huang, X. Liu, M. Van Damme, K. Yang, and M. Zondlo, A physics-based approach to oversample multi-satellite, multispecies observations to a common grid, ***Atmospheric Measurement Techniques***, 11, 6679–6701, doi:10.5194/amt-11-6679-2018, 2018.

9. **K. Sun**, I. Gordon, C. Sioris, X. Liu, K. Chance, and S. Wofsy, Reevaluating the use of O_2 $a^1\Delta_g$ band in spaceborne remote sensing of greenhouse gases, ***Geophysical Research Letters***, 45, 5779–5787, doi:10.1029/2018GL077823, 2018.

10. **K. Sun**, X. Liu, G. Huang, G. González Abad, Z. Cai, K. Chance, and K. Yang, Deriving the slit functions from OMI solar observations and its implications for ozone-profile retrieval, ***Atmospheric Measurement Techniques***, 10(10), doi:10.5194/amt-10-3677-2017, 2017.

(d) Synergistic Activities

1. **Mentoring and advising:** (i) Graduate Adviser for Nima Masoudvaziri (Ph.D. candidate, Dept. of Civil, Structural & Environmental Engineering, University at Buffalo), Zolal Ayazpour (Ph.D. student, Dept. of Civil, Structural & Environmental Engineering, University at Buffalo), and Chantelle Lonsdale (Ph.D. student, Dept. of Civil, Structural & Environmental Engineering, University at Buffalo). (ii) Thesis committee member for Xiangyu Jiang and Qiang Pu (Ph.D. candidates, Dept. of Geography, University at Buffalo). (iii) Mentor for NSF REU students: Victor Fu (2014), University of Southern California; Levi Stanton (2014), Princeton University; Oshare Mcrae (2011), Vanderbilt University; Jeff Schreiber (2010), University of Dayton. (iv) Mentor for senior thesis: Michelle L. Yakubisin (2013–2014), Princeton University; Emma Bedard (2010–2011), Princeton University. (v) Scientific mentor for Lars Wendt, summer intern at Princeton and teacher at Hunterdon Central Regional High School, Flemington, NJ (2013).

2. **University service:** (i) Officer of Student Leadership Council in Center for Mid-Infrared Technologies for Health and the Environment (MIRTHE), NSF-ERC. (ii) Co-founder and former board member of Princeton University China Energy Group. (iii) Co-PI of NSF's Student-Led Independent Project (SLIP), EEC-0540832: "A Multi-Sensor Field Deployment for Assessing Anthropogenic Influences on Carbon, Nitrogen and Water Cycling", served as leading field coordinator in 2012–2013.

3. **Community service:** (i) Proposal reviewer for NASA ROSES and NOAA AC4 programs. (ii) Attendee of the 14th Atmospheric Chemistry Colloquium for Emerging Senior Scientists (ACCESS XIV).

4. **Development of research tools:** (i) Developed open-source software to merge multi-satellite, multi-species observations to regular grid. Maintained a GitHub repository at `https://github.com/Kang-Sun-CfA/Oversampling_matlab`.

5. **Teaching:** (i) Instructor for CIE 546–Environmental Fluid Mechanics at University at Buffalo. (ii) Instructor for CIE 532–Statistical methods in Environmental and Water Resources Engineering at University at Buffalo. (iii) Instructor for CIE 461/563–Air Pollution

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EDUCATION

Utrecht University, Utrecht, The Netherlands	PhD	12/2013
Peking University, Beijing, China	MS	07/2009
Tianjin University, Tianjin, China	BS	07/2006

ACADEMIC APPOINTMENTS

2018 – Present	Assistant Professor, University at Buffalo, Buffalo, NY
2018 – Present	Affiliated Assistant Professor, University of Washington, Seattle, WA
2014 – 2018	Senior Fellow, University of Washington, Seattle, WA

RECENT GRANT

NIH\NIEHS 1R01ES031986-01A1 Meng Wang (PI) 07/2021 – 4/2026
Air Pollution, Coronary Events and Atherosclerotic Progression in a Susceptible Population
The goal of the proposed study is to investigate the effect of exposure to air pollution on coronary heart disease and the mediation pathways through atherosclerotic progression in susceptible patients of cardiovascular diseases.
Role: Principal Investigator

PERSONAL STATEMENT

Dr. Meng Wang is an environmental health scientist with expertise in: 1) exposure assessment relating to monitoring and modeling exposure to air pollution; 2) health effects of exposure to air pollution and built environment for susceptible population such as elderly adults and patients with diseases; and 3) climate change impacts on air pollution and disease burden under future scenarios. He has more than 15 years of experience in environmental health studies and has more than 55 publications to date, many of which were published in top-tier journals on environmental health sciences, such as JAMA and Environmental Health Perspectives.

PEER-REVIEWED JOUNRAL ARTICLES

Complete List of Published Work in Google Scholar:
https://scholar.google.com/citations?hl=en&user=AU6UVKcAAAAJ

Selected Publications (* denotes corresponding author; # denotes co-first author)

1. Xu J, Yang W, Bai ZP, Zhang RY, Zheng J, **Wang M***, Zhu T. Modeling spatial variation of gaseous air pollutants and particulate matters in a Metropolitan area using mobile monitoring data. Environmental Research 2022; 210: 112858.
2. Hu HB, Hou ZH, Huang CH, LaMonte MJ, **Wang M***, Lu B. Associations of exposure to residential green space and neighborhood walkability with coronary atherosclerosis in Chinese adults. Environmental Pollution 2021; 292(Pt A):118347.
3. Wang YY, Hu JL, Zhu J, Li JY, Q ME, Liao H, Chen K, **Wang M***. Health Burden and economic impacts attributed to PM2.5 and O3 in China from 2010 to 2050 under different representative concentration pathway scenarios. Resources, Conservation & Recycling, 2021; 173:105731.
4. Huang CH, Hu JL, Xue T, Xu H, **Wang M***. High-Resolution Spatiotemporal Modeling for Ambient PM 2.5 Exposure Assessment in China from 2013 to 2019. Environmental science & technology 2021; 55(3): 2152-2162.
5. Wang YY, Li X, Shi ZH, Huang L, Li JY, Zhang HL, Ying Q, **Wang M,** Ding DP, Zhang XL, Hu JL. Premature Mortality Associated with Exposure to Outdoor Black Carbon and Its Reduction Efficiency in China. *Resources, Conservation & Recycling,* 2021; 170:105620.
6. Chen K[#], **Wang M**[#], Huang C, Kinney PL, Anastas PT. Air pollution reduction and mortality benefit during the COVID-19 outbreak in China. *Lancet Planet Health* 2020;4(6):e210-e212.
7. **Wang M**, Aaron CP, Madrigano J, Hoffman EA, Angelini E, Yang J, Laine A, Vetterli TM, Kinney PL, Sampson PD, Sheppard LE, Szpiro AA, Adar SD, Kirwa K, Smith B, Lederer DJ, Diez-Roux AV, Vedal S, Kaufman JD, Barr RG. Association between long-term exposure to ambient air pollution and change in quantitatively assessed emphysema and lung function. *JAMA*. 2019;322:546-556.
8. **Wang M*,** Sampson PD, Sheppard LE, Stein JH, Vedal S and Kaufman JD. Long-Term Exposure to Ambient Ozone and Progression of Subclinical Arterial Disease: The Multi-Ethnic Study of Atherosclerosis and Air Pollution. Environ Health Perspect. 2019;127:57001.
9. **Wang M***, Sampson PD, Hu J, Kleeman M, Keller JP, Olives C, Szpiro AA, Vedal S, Kaufman JD. Combining Land-Use Regression and Chemical Transport Modeling in a Spatiotemporal Geostatistical Model for Ozone and PM2.5. Environmental science & technology 2016; 50: 5111-5118. PMID: 27074524
10. **Wang M***, Gehring U, Hoek G, Keuken M, Jonkers S, Beelen R, Eeftens M, Postma DS, Brunekreef B. Air Pollution and Lung Function in Dutch Children: A Comparison of Exposure Estimates and Associations Based on Land Use Regression and Dispersion Exposure Modeling Approaches. Environmental health perspectives 2015; 123: 847-851.
11. **Wang M**, Zhu T, Zheng J, Zhang RY, Zhang SQ, Xie XX, Han YQ, Li Y. Use of a mobile laboratory to evaluate changes in on-road air pollutants during the Beijing 2008 Summer Olympics. Atmos Chem Phys 2009; 9: 8247-8263.

Curriculum Vitae

Susan Grinslade, PH.D, RN, PHN-CS, BC

Clinical Professor,
Member, Graduate Faculty
University at Buffalo, The State University of New York
School of Nursing
211 Wende Hall
Buffalo, NY 14214

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Education

University of Illinois at Chicago, Chicago, IL 2005
PhD Nursing Science
Dissertation: "Development of a Model Using Sociocognitive Variables to Explain Self-Care in Adult Women with Type 2 Diabetes"

Center for Health Promotion Research, University of Texas, Austin, TX 2001
Fellowship Health Promotion Research

Southern Illinois University at Edwardsville, IL 1990
M.S., Medical-Surgical Nursing Specialty Tract: Clinical Specialist, Nursing Education

Southern Illinois University at Edwardsville, IL 1975
M.S.Ed., Human Services Program Development & Counselor Education

Southern Illinois University at Edwardsville, IL 1972
B.S.N., Nursing

Barnes Hospital, School of Nursing, St. Louis, MO 1969
Diploma, Nursing

Board Certification

American Nurses Credentialing Center (ANCC) 2005
Community/Public Health Clinical Specialist #2005008555 **December 1, 2020 – November 30, 2025**

Research Activities

Area of Research

Women's Health, Diabetes Self-care, Self-efficacy, Social support, Health beliefs, Health Services Research, Nursing Education, Social Determinants of Health, Health Equity, Mental Health

Grant support

Current
PICORI
Comparing two ways to mitigate the impact of the COVID-19 on mental health among adults from underserved and racial / minority communities. 11/01/2020 – 11/30/2023
Role: Co-I: In this capacity I work directly with the PI and Community Engagement Coordinator to facilitate engagement, communication, and work collaboratively to keep Community Stakeholders appraised of research activities and mitigate any concerns with the stakeholders.

PICORI
Building research capacity: Engaging underserved and racial minorities for improved mental health during and after COVID. 11/01/2021 – 4/30/2023 Role: Co-I: In this capacity I work collaborate with PI and Community Engagement Coordinate to facilitate delivery of grant modules and mitigate concerns with the stakeholders.

Previous Support

CDC-RFA-DP18-1813
Project Title: REACH (Racial and Ethnic Approaches to Community Health
Source: AHRQ Grant number 1 R03 HS023672001A1
Period: 2018 – 2020
Brief description of project goals: The REACH Ferry Good Health Project is implemented through CAI Research and Evaluation to address disparities in chronic disease and social determinants of health through focus areas of reduction of smoking and tobacco use, promote healthy nutrition and breastfeeding resources, and improve clinical linkages and health referral assets. Research activities using a community based participatory approach will concentrate on East Side of Buffalo and five disparate zip codes along the Ferry Street corridor.
Role: Co-Lead for Clinical Linkages

Selected Publication

a. Raines, D., Grinslade, S., Fabry, D., Hewner, S., & Steeg, L. (2016). Knowledge and Attitudes of RN-BSN Students Before and After a Patient Safety Course. Nursing Education Perspectives 37(6), 317-319.

b. Grinslade, S., Paper, B., Jing, H., Quinn, L. (2015). Development and psychometric evaluation of the diabetes self-efficacy scale. Journal of Nursing Measurement, 23(1), 40-56.

c. Castner, J., Grinslade, S., Guay, J., Hettinger, A., Seo, J., & Boris, L. (2013). Registered nurse scope of practice and emergency department complaint specific protocols. Journal of Emergency Nursing, 39 (5), 467-473.

d. Kavookijian, J., Hill, S., Chan, M., & Grinslade, S. (2012). Translating research into practice: Interpreting comparative effectiveness studies: Number needed to treat and number needed to harm. AADE In Practice. Published on-line:

e. AADE Behaviour Score Work Group. (2011). Addressing the Need for an Instrument to Measure Behaviour Change Instrument in Diabetes Self-Management Education. White Paper published AADE on-line http://www.diabeteseducator.org/export/sites/aade/_resources/pdf/research/Behavior_Score_Document_White_Paper_2011.pdf

f. Wisnewski, C., Boren, S., Grinslade, M., et al. (2011). AADE Technical Review: Diabetes Self-Management Education and Training (DSME/T) Outcomes Measures. Position Statement published AADE on-line http://www.diabeteseducator.org/export/sites/aade/_resources/pdf/publications/Outcomes_Technical_Review_Aug.pdf

g. Steeg, L., Grinslade, S., Vari, C., Glica, B. A., Meyers, C., and Jennings, J. (2011). A Dedicated Education Unit: From Implementation and Beyond. Journal of Professional Nursing.

h. Baldwin, K., Grinslade, M., Watts, P., Dinger, M., McCubbin, J., & Baer, L. (2005). Use of Higher-Order Factor Analysis with Dichotomous Data. Research in Nursing and Health, 28, 431-440.

i. Baer, L. C., Baldwin, K. A., Sisk, R. J., Watts, P., Grinslade, M. S., Brockschmidt, B., Dinger, M. K., Marion, L. N., & McCubbin, J. (1999). Development of an instrument to measure community acceptance of NPs and PAs. Journal of Nursing Measurement, 7(1), 63-78.

j. Grinslade, S. & Buck, E. (1999). Diabetic ketoacidosis: Implications for the Medical-Surgical nurse. MedSurg Nursing, 8(1), 37-45.

k. Davila, Y., Bonilla, E., Gonzales-Ramirez, D., Grinslade, S., & Villarruel, A. (2008). Pilot Testing HIV-IPV Prevention Modules among Spanish-Speaking Latinas. *Journal of the Association of Nurses in AIDS Care,* 19(3), 219-224.

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2. Guarnieri, M. and J.R. Balmes. Outdoor air pollution and asthma. *The Lancet.* 2014;383(9928):1581-1592.
3. Braithwaite, I., S. Zhang, J.B. Kirkbride, D.P.J. Osborn, and J.F. Hayes. Air pollution (particulate matter) exposure and associations with depression, anxiety, bipolar, psychosis and suicide risk: a systematic review and meta-analysis. *Environmental health perspectives.* 2019;127(12):126002.
4. Demetillo, M.A.G., A. Navarro, K.K. Knowles, K.P. Fields, J.A. Geddes, C.R. Nowlan, S.J. Janz, L.M. Judd, J. Al-Saadi, and K. Sun. Observing nitrogen dioxide air pollution inequality using high-spatial-resolution remote sensing measurements in houston, Texas. *Environmental Science & Technology.* 2020;54(16):9882-9895.
5. Demetillo, M.A.G., C. Harkins, B.C. McDonald, P.S. Chodrow, K. Sun, and S.E. Pusede. Space-Based Observational Constraints on NO2 Air Pollution Inequality From Diesel Traffic in Major US Cities. *Geophysical Research Letters.* 2021;48(17):e2021GL094333.
6. Taylor Jr, H.-L., J.-K. Jung, and E. Dash. THE HARDER WE RUN2021.
7. Fox, J. and G. Monette. Generalized collinearity diagnostics. *Journal of the American Statistical Association.* 1992;87(417):178-183.
8. Gehring, U., A.H. Wijga, M. Brauer, P. Fischer, J.C. de Jongste, M. Kerkhof, M. Oldenwening, H.A. Smit, and B. Brunekreef. Traffic-related air pollution and the development of asthma and allergies during the first 8 years of life. *American journal of respiratory and critical care medicine.* 2010;181(6):596-603.
9. Landrigan, P.J., R. Fuller, N.J.R. Acosta, O. Adeyi, R. Arnold, A.B. Baldé, R. Bertollini, S. Bose-O'Reilly, J.I. Boufford, and P.N. Breysse. The Lancet Commission on pollution and health. *The lancet.* 2018;391(10119):462-512.
10. Jerrett, M., K. Shankardass, K. Berhane, W.J. Gauderman, N. Künzli, E. Avol, F. Gilliland, F. Lurmann, J.N. Molitor, and J.T. Molitor. Traffic-related air pollution and asthma onset in children: a prospective cohort study with individual exposure measurement. *Environmental health perspectives.* 2008;116(10):1433-1438.
11. Gaffney, A.W., D.U. Himmelstein, D.C. Christiani, and S. Woolhandler. Socioeconomic inequality in respiratory health in the US From 1959 to 2018. *JAMA Internal Medicine.* 2021;181(7):968-976.
12. Yoo, E.-H., A. Zammit-Mangion, and M.G. Chipeta. Adaptive spatial sampling design for environmental field prediction using low-cost sensing technologies. *Atmospheric Environment.* 2020;221:117091.
13. Cressie, N. and G. Johannesson. Fixed rank kriging for very large spatial data sets. *Journal of the Royal Statistical Society: Series B (Statistical Methodology).* 2008;70(1):209-226.
14. Di, Q., H. Amini, L. Shi, I. Kloog, R. Silvern, J. Kelly, M.B. Sabath, C. Choirat, P. Koutrakis, and A. Lyapustin. An ensemble-based model of PM2. 5 concentration across the contiguous United States with high spatiotemporal resolution. *Environment international.* 2019;130:104909.
15. Eum, Y., E. Yoo, and E. Bowen. Socioeconomic determinants of pediatric asthma emergency department visits under regional economic development in western New York. *Social Science & Medicine.* 2019;222:133-144.
16. Yoo, E.-H., P. Brown, and Y. Eum. Ambient air quality and spatio-temporal patterns of cardiovascular emergency department visits. *International journal of health geographics.* 2018;17(1):1-16.
17. Yoo, E.-h., Q. Pu, Y. Eum, and X. Jiang. The impact of individual mobility on long-term exposure to ambient pm2. 5: assessing effect modification by travel patterns and spatial variability of pm2. 5. *International journal of environmental research and public health.* 2021;18(4):2194.

18. Lu, Y., G. Giuliano, and R. Habre. Estimating hourly PM2. 5 concentrations at the neighborhood scale using a low-cost air sensor network: A Los Angeles case study. *Environmental Research.* 2021;195:110653.
19. Zimmerman, N. Tutorial: Guidelines for implementing low-cost sensor networks for aerosol monitoring. *Journal of Aerosol Science.* 2022;159:105872.
20. Kumar, V. and M. Sahu. Evaluation of nine machine learning regression algorithms for calibration of low-cost PM2. 5 sensor. *Journal of Aerosol Science.* 2021;157:105809.
21. Xu, J., W. Yang, Z. Bai, R. Zhang, J. Zheng, M. Wang, and T. Zhu. Modeling spatial variation of gaseous air pollutants and particulate matters in a Metropolitan area using mobile monitoring data. *Environmental Research.* 2022;210:112858.
22. Hoek, G., R. Beelen, K. De Hoogh, D. Vienneau, J. Gulliver, P. Fischer, and D. Briggs. A review of land-use regression models to assess spatial variation of outdoor air pollution. *Atmospheric environment.* 2008;42(33):7561-7578.
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24. Wang, M., P.D. Sampson, J. Hu, M. Kleeman, J.P. Keller, C. Olives, A.A. Szpiro, S. Vedal, and J.D. Kaufman. Combining land-use regression and chemical transport modeling in a spatiotemporal geostatistical model for ozone and PM2. 5. *Environmental science & technology.* 2016;50(10):5111-5118.
25. Veefkind, J.P., I. Aben, K. McMullan, H. Förster, J. De Vries, G. Otter, J. Claas, H.J. Eskes, J.F. De Haan, and Q. Kleipool. TROPOMI on the ESA Sentinel-5 Precursor: A GMES mission for global observations of the atmospheric composition for climate, air quality and ozone layer applications. *Remote sensing of environment.* 2012;120:70-83.
26. Sun, K., L. Zhu, K. Cady-Pereira, C. Chan Miller, K. Chance, L. Clarisse, P.-F. Coheur, G. González Abad, G. Huang, and X. Liu. A physics-based approach to oversample multi-satellite, multispecies observations to a common grid. *Atmospheric Measurement Techniques.* 2018;11(12):6679-6701.
27. BuffaloNews, *Editorial: A force for good*, in *"Citizens of Erie County should not have their life expectancy determined by Zip code"*. 2019, The Buffalo News: Buffalo, NY.
28. Pu, Q. and E.-H. Yoo. Ground PM2. 5 prediction using imputed MAIAC AOD with uncertainty quantification. *Environmental Pollution.* 2021;274:116574.

Quality Assurance and Quality Control Statement

We will apply quality control procedures with an emphasis on detailed documentation and multi-platform validation in all aspects of the project to ensure accuracy and high quality of our research products to satisfy each proposed aim. We will also ensure the research efforts and deliverables for each proposed component comply with EPA Quality Standards.

Responsible individual for the quality assurance (QA) and quality control (QC)

Dr. Yoo will oversee all the proposed research activities and be responsible for the overall QA/QC aspects, information coordination, integration across objectives, and completion and summarization of all the project components. She has served this role for the previous University at Buffalo RENEW project and NIH projects (R21 ES017826 and R01GM108731) that supported her low-cost sensor deployment project and GPS-enabled mobile phone-based health studies, respectively. Drs. Wang, Sun, and Grinslade will assist in the process, with a focus to collect low-cost air sensor measurements at fine spatial and temporal resolution and further ensure the proper usage and interpretation of the collected air monitoring data. More specifically, Dr. Grinslade will facilitate the meetings with community members and collect community inputs for an optimal spatial sampling site design and its implementation. Dr. Wang will lead the effort of mobile air quality monitoring that will facilitate the calibration of both the low-cost PurpleAir (PA) sensor measurements of $PM_{2.5}$ and satellite-derived NO_2 exposure estimates led by Dr. Sun. Dr. Yoo will apply an oral report and assessment format in each team meeting with the support from the Project Coordinator, which will allow a timely correction action, and enforce a written quality report to be submitted along with the science progress report every three months in quarterly progress reports. Dr. Yoo will oversee the air pollution monitoring and intervention campaign, survey data collection, and community outreach and education events.

Project quality objectives and evaluation of success

We hypothesize that disproportionate exposure to toxic air deteriorate community health of children, pregnant women, and adults with pre-existing conditions, especially in underserved communities. However, a lack of spatially and temporally resolved air quality data collected within the community hampers the efforts to establish the causal associations between air pollution exposures and adverse health effects. Therefore, the overall goal of the proposed research is to improve the availability and resolution of air pollution data of underserved communities in New York (NY), focusing on Buffalo African-American community in Erie County, NY. Detailed objectives are included in the research statement. The quality objectives include:

Aim 1. Demonstrate our optimal spatial sampling design can provide accurate, high-resolution $PM_{2.5}$ concentration data under the limited number (N = 30) of PA air sensors at each sampling campaign, which will provide the information on the spatial gradients of air pollutant concentrations that will in turn be used to identify potential sources of major emissions and hotspots. We will assess the optimality of sampling site selection by comparing the prediction uncertainty and the utility function score used in the adaptive spatial sampling strategy from a scenario where the monitoring sites are selected at random.

Aim 2. Collect spatially and temporally resolved air pollution data and calibrate the raw measurements to obtain reasonable accuracy. We will conduct a rigorous evaluation of the raw PA sensor measurements of $PM_{2.5}$ concentrations before and after the calibration whose procedures are explained below, and the results will be documented in the report and submitted to a proper outlet (e.g., Environment International, Environmental Science and Pollution Research, and GeoHealth).

Aim 3. Synthesize both real-time $PM_{2.5}$ sensor measurements with existing $PM_{2.5}$ monitoring data from AQS, meteorological conditions, land use data, traffic volume for spatially resolved hourly $PM_{2.5}$ exposure estimation. Similarly, we will estimate daily NO_2 exposure estimate at 250 m resolution. We will document all the model specification, validation, and performance in quarterly reports/final report as well as manuscripts.

Aim 4. We will document all community meetings (three times per year) that include the meetings with community leaders, community stakeholders, and residents, and include these documents in quarterly reports and the final report. We will also share and disseminate the research findings, including both the collected data and air pollution hotspots in space and time, in the website that research team will create and maintain, in annual reports, local news articles, and peer reviewed journal articles.

Quality Control of air monitoring data

For the quality objectives involved in each research component, the PI and the three Co-PIs will apply cross peer review to help inspect and evaluate the study design and analytical/evaluation methods performed by the other team members. The framework of data quality control for low-cost PA sensor measurements of $PM_{2.5}$ and satellite-derived NO_2 are summarized below. Each PA sensor is equipped with two Plantower PMS 5003 laser sensors and a BME280 sensor that generate two sensor measurements of particulate matter (Channel A and B $PM_{2.5}$ in $\mu g/m^3$), temperature (°C), and relative humidity (%).

(a) Low-cost $PM_{2.5}$ sensor calibration

We will develop a rigorous and feasible quality control scheme using both channels' readings of $PM_{2.5}$ to minimize outliers and eliminate malfunctioning sensors or readings. Our approach closely follows Lu et.al. (2021) that estimated hourly $PM_{2.5}$ concentrations at local level using a PA sensor network in Los Angeles.

First, we will identify malfunctioning sensors with unusually *low rate of changes* in their readings over time. We will calculate the centered 7-hour moving squared difference $(\gamma_t), t = 1, \ldots, 24$ of PA $PM_{2.5}$ measurements and will discard all hourly records if the sensor measurements remain the same over 7 hours.

$$\gamma_t = \frac{1}{2n_t} \sum_{t-3<t_i,t_j<t+3} [x_{t_i} - x_{t_j}]^2$$

where n_t denotes the number of observations available between time $(t-3$ and $t+3)$ where x_{t_i}represents the PA sensor measurement obtained at time t_i.

Second, we will discard $PM_{2.5}$ outliers that are extreme that exceed the sensor's effective measurement range ($> 500\ \mu g/m^3$ or $< 0\ \mu g/m^3$) in both channels. We will also examine the temperature and relative humidity and any data record associated with extreme values of relative humidity and temperature will be discarded. Next, we will calculate median $(\tilde{X})$and median absolute deviation (MAD) per channel within a calendar month. Considering the channel specific monthly MAD and its multiple as a threshold, we will discard local outliers. That is, any PA $PM_{2.5}$ measurements that is less than equal to $\tilde{X}$-3*MAD or greater than $\tilde{X}$+3*MAD will be discarded.

We also expect that there will be time periods of data loss or prolonged interruption due to power outrages or data communication loss during the study period. We will detect the measurement data corresponding to these events and discard the records. Specifically, we will examine the monthly data completeness and we will consider the data loss if it is less than 75% per channel for each PA sensor.

Forth, we will evaluate the degree of agreement from dual-channel readings for each sensor within a given month and calculate statistical anomaly detection indicators, including the coefficient of determination, mean absolute error and mean absolute percentage error. If these metrics are below the thresholds set for the present study, we will discard the values. In addition, we will perform a linear regression of hourly readings for each sensor with its neighboring PA sensors within 3 km. This will ensure the quality control remaining sensor readings with data available from only one channel.

Lastly, we will compare the PA sensor measurements with mobile monitoring measurements. We will calculate the summary statistics, such as correlation coefficient, between two sources and we will investigate the sources of disparity if they are larger than expected.

(b) Satellite-derived NO_2 calibration

Troposphere column of NO_2 measured by satellite sensors will be validated by the Pandora spectrometer instrument deployed at the University at Buffalo north campus. Dr. Sun is the PI of the Pandora instrument, which is part of a global network (Pandora Global Network, PGN) that is widely used for satellite validation and calibration. The satellite observations will also be collocated and correlated with stationary and mobile ground-based NO_2 measurements. We will intercompare the disparity of NO_2 exposure derived from satellite and mobile spatial mapping of NO_2.

Cover Page

Project Title: Improving air quality monitoring for Buffalo African-American community

Applicant Information:
University at Buffalo, SUNY
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Set-aside: "No set-aside"

Brief Description of applicant organization: The University at Buffalo (UB), as the flagship and largest university within the State University of New York (SUNY) public university system, is a diverse, inclusive scholarly community dedicated to bringing the benefits of research, scholarship, and education excellence to local and global communities in ways that impact and positively change the world. UB RENEW (Research and Education in Energy, Environment and Water) Institute is university-wide and interdisciplinary, focusing on complex energy and environmental issues, as well as the social and economic ramifications. It helps develop and coordinate innovative research, education and outreach programs.

Project location: Buffalo, NY

Air pollutant scope: $PM_{2.5}$, NO_2

Budget summary:

EPA Funding Requested	Total Project cost
$499,963	$499,963

Project Period: 11/1/2022 – 10/31/2025

Short Project Description: We will improve air monitoring in the Buffalo African-American community in Buffalo, NY, and share the research findings with community members. To achieve this goal, we will deploy low-cost ambient air pollution sensors at optimal sampling sites in the residence of the marginalized community and develop the community-specific air quality prediction model by integrating the collected sensor measurements with existing data. We expect that the proposed project will improve the availability and resolution of community-specific air quality data, which will in turn convert into quantitative and qualitative information useful to develop interevent adverse health outcomes, particularly for vulnerable population, in the community.

1. Project Summary and Approach

A. Project Overview

The adverse health effects of environmental exposure to toxic air pollutants are well-documented,[1-3] although little is known about the contexts of exposures, including who are the most disproportionately affected by which air pollutant and what are the major contributors to air pollution. Growing evidence suggests that the communities most affected by poor air quality are typically underserved, racial and ethnic minorities with low income.[4, 5] However, efforts to establish the causal role of air pollution exposure on adverse health outcomes of the marginalized communities has been hampered by the lack of localized and concurrent community-specific air quality data. Consequently, the resulting health impacts have been devastating particularly for the susceptible subgroups, including children, pregnant women, and adults with pre-existing conditions, of marginalized communities.

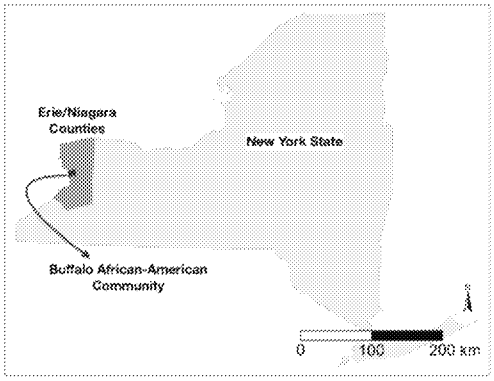

Figure 1. The Buffalo African-American Community located within the Erie-Niagara Region, New York

The African-American community residing in the east side of the city of Buffalo, New York (NY), has been susceptible to chronic disease causing *10-12 lost years of life* relative to community members in the neighboring regions. They also experienced disproportionately higher rates of exposure, illness, and hospitalization and death-related to COVID-19. The recent report[6] from the University of Buffalo (UB) Center for Urban Studies concluded that the Black Buffalo community ('the African-American community in the city of Buffalo') has long suffered from and remains vulnerable to high unemployment rates, poverty, low income and education achievement, and poor housing condition, which have led to increasing susceptibility to environmental exposure and declining health. Specifically, there have been extremely high rates of asthma hospitalization of children (0-17 years old) in this community (i.e., 46.9% asthma hospitalizations of Black youth per 10,000 between 2016 and 2018) in comparison to other races (i.e., 10.2% of White youth) in the region and these outcomes were linked to poor air quality.[7]

Meanwhile, none of the three active U.S. Environmental Protection Agency (EPA) monitoring stations in Erie/Niagara Counties is located within this community, and thus it is difficult to discern the community-specific air pollution exposures. The Erie-Niagara region within which the Buffalo African-American community (see Figure 1) is situated includes several affluent residential neighborhoods that are far away from industrial and mobile sources of pollution. Given that the region-wide air pollution concentration levels are quantified as an average of the air quality from all the communities within the region, the Erie/Niagara Counties have not been labeled as non-attainment areas by EPA. Consequently, the environmental deterioration of this community, including exposures to toxic air pollutants, has drawn little attention to date.

As a first step to address this chronic and significant environmental health disparity, we propose to *improve the availability and resolution of environmental pollution data*. More specifically, we will (1) design an optimal spatial sampling strategy for the placement of low-cost portable air pollution sensors (for fine particulate matter $PM_{2.5}$); (2) collect ambient air pollution data within the Buffalo African-American community; (3) determine community-specific air pollution exposures by integrating the sensor measurements with existing data; (4) disseminate research findings with community residents to mitigate adverse health outcomes from the exposure to toxic air, particularly for vulnerable subpopulation, and provide evidence to develop pollution control and reduction plans/policies.

We expect that the spatially and temporally resolved air quality data will be used in health research, enabling investigators to quantify and account for various sources of uncertainties in exposure estimates to potentially increase the accuracy and reproducibility of research findings. Further, the results of this project will increase the ability to mitigate the effects of environmental exposure by developing coping strategies in the short term, but also potentially help set regulatory standards to protect the health of this marginalized community in the longer term.

B. Project Significance

There is strong evidence to support links between air pollution exposure and the development of asthma in children.[8-10] Across the United States, the air quality has improved over the past half century, although socioeconomic disparities in respiratory disease remain. For example, Gaffney et.al[11] reported that the difference between the prevalence of childhood asthma in the poorest and the wealthiest has increased 4.9% over the last 40 years in U.S. This increased socioeconomic disparity in respiratory health is likely due to *persistent disparities in exposures to unclean air, dusts and gases*, nutrition, and access to health care, or other factors. However, our ability to establish causality between poor air quality and high prevalence of respiratory disease is limited in the marginalized communities due to the lack of spatially continuous, temporally resolved measurements of air pollutants that capture gradients within/between neighborhoods. In the proposed study, we aim to fill this gap by increasing data availability using low-cost air pollution sensors and improving their resolution using advanced modeling techniques through a community-based participatory approach.

We expect that the proposed research will increase the awareness of the adverse effects of air pollution on health among Buffalo's African-American community members, and improve our understanding of the local variations of air pollutant levels in the community. We will identify the air pollution hotspots where and when the incidences of extremely high air pollution concentrations occur in comparison to the EPA's ambient air quality standard (e.g., 12 $\mu g/m^3$ for $PM_{2.5}$) and assess the drivers that affect intraurban variability of the air pollution. Our optimal sampling site selection approach, which will include community priorities in addition to the proximity to existing pollution sites and hazards, will partially address the community concerns. Our spatially and temporally-resolved multi-pollutant maps will also be used to develop intervention strategies to reduced adverse health conditions of the community and further can be used to develop pollution control or reduction policies.

C. Approach

The proposed project aims to increase the availability and resolution of air quality data of the east side of Buffalo, NY, which are predominantly African-Americans neighborhoods (on average 70 % African-American according to 2019 American Community Survey (ACS) 5-year estimates), by supplementing EPA monitoring measurements with additional data sources. To maximize the utility of limited resources (i.e., the fixed number of sensors and the cost for their maintenance), we will design adaptive spatial sampling strategies where we incorporate community environmental health concerns in addition to other risk-factors and prediction uncertainty (Aim 1). Over the two waves of the monitoring campaign, we will collect real-time $PM_{2.5}$ measurements from low-cost PurpleAir (PA) sensor network and mobile air quality monitoring (Aim 2). The collected sensor measurements will be integrated with existing data (satellite-derived aerosol optical depth (AOD) and nitrogen dioxide (NO_2), the EPA's Air Quality System (AQS) database, and other auxiliary data) to assess community-specific exposures to air pollutants (Aim 3). To inform the community about the research findings, we will develop a website of accurate and localized air quality index that community members can check and also send text messages/alarms when the incidences of high levels of air pollutants occur so that community members can adjust their activities accordingly (Aim 4).

Aim 1. Design an optimal spatial sampling strategy for low-cost air pollution sensor placement

We will conduct two waves of a year-long monitoring campaign at a total of 60 sampling sites by deploying PA sensors (30 sensors per monitoring campaign). The selection of optimal monitoring sites is critical. To determine optimal sampling sites, we will consider multiple factors, including inputs gathered from community members regarding their environmental concerns and issues, while minimizing exposure misclassification error. We will seek community input from our meetings with community leaders, grassroot organizations, and interviews and surveys with community members. This information will be used as a key risk-factor criterion to develop the adaptive spatial sampling design described in Yoo et.al., (2020).[12] Essentially, we will develop a spatial sampling design strategy based on a utility function that combines prediction uncertainty and risk factor criteria including the inputs from the community and spatially varying risk of adverse health outcomes, such as the relative risk of children's hospitalizations for asthma. The prediction uncertainty will be quantified through a spatial data fusion approach based on a fixed rank kriging[13] that efficiently tackle data with different spatial resolutions and measurement errors. For a retrospective health studies, we will use existing $PM_{2.5}$ model

predictions that are available at 1x1 km^2 gridded daily mean for the study region during 2010 – 2016 from an ensemble-based model, which integrated three machine learning algorithms (i.e., neural network, random forest, and gradient boosting) and had good performance with a 10-fold cross validated R^2 of 0.86 for $PM_{2.5}$ predictions.[14] We will also incorporate auxiliary data, including land cover, elevation, population density, major road lengths, as well as demographic and socioeconomic conditions of the study area from U.S. Census. In addition, we will take into account the risk management plan (RMP) facility proximity from the EJScreen tools from EPA and Social Vulnerability Index from Centers for Disease Control and Prevention (CDC).

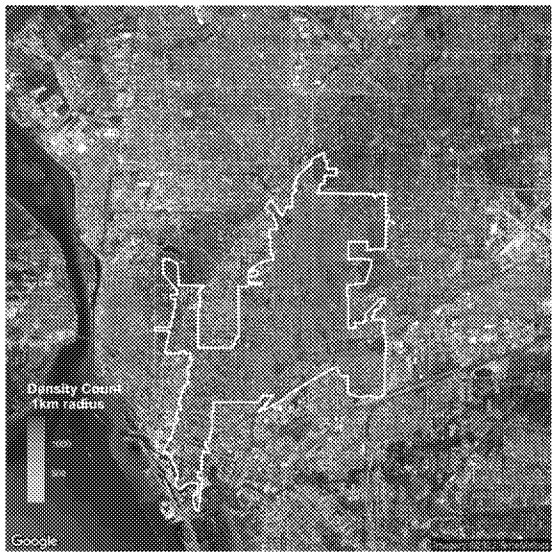

Figure 2. The density of ER visits for asthma in Buffalo African-American community (delineated by the white border) and its surrounding during 2010-2016. The purple markers show the locations of three EPA regulatory monitors for $PM_{2.5}$ (2022).

One of the key pieces of information required for an adaptive spatial sampling design is a set of candidate sites for air quality monitoring. The adaptive sampling algorithm selects the optimal monitoring sites (N = 30) from the candidate sites after taking into consideration the feasibility and the multiple objectives of the study. In the proposed study, candidate sites will be chosen based on both the community participation (recruitment) and the results from a retrospective health study of on both inpatient hospitalization and outpatient care for asthma. Specifically, we will examine Emergency Room (ER) visit records from 2010 to 2016 and identify local hotspots of respiratory disease while accounting for the age-adjusted concurrent population distribution. For example, Figure 2 illustrates the spatial kernel density of ER visits for asthma between 2010-2016 where the spatial gradients of risk for asthma exacerbations are clearly illustrated. The selection of candidate sites will also depend on community participation. We will recruit the study participants through our research team's participation of the annual conference (i.e., "Igniting Hope") and religious meetings where community members are actively engaged, but we will also use a traditional means of recruitment, such as flyers posted in community boards and the word of mouth, particularly through the network that the project advisory committee has developed over years.

Our team has multi-year experiences of model development and sensor deployment. Dr. Yoo has developed an adaptive spatial sampling design[12] for an optimal placement of low-cost air pollution sensors, and conducted epidemiological studies for children's asthma using ER visits for outpatient care,[15] the elderly's cardiovascular disease,[16] and long-term air pollution exposure studies combined with their mobility[17] in the study area.

Aim 2. Collect ambient air pollution data at the Buffalo African-American community

In each wave of monitoring campaign, our research team will visit the study participant's home and install the PA sensor outside of the residence. Prior to the installation, we will get consensus about the visits for installation and maintenance, and we will also ask for the preferred location for the installation of the sensor. Throughout data collection, we will make regular visits to check and communicate with participants about their concerns and other technical problems (e.g., malfunction of the sensor operation), or a loss/damage of the sensor installed in their residence.

PA sensors rely on light scattering to determine concentrations. Specifically, each PA sensor contains two Plantower PMS 5003 laser sensors to measures light scattering, which is in turn converted to mass concentration of particulate matter. Due to the known limitations of optical sensors, such as their limited ability to detect particle size distribution and shape, as well as their sensitivity to surrounding environments, we will conduct the calibration of sensor measurements.[18-20] According to the manufacturer, the effective measurement range of $PM_{2.5}$ for PA sensor is between 0 and 500 $\mu g/m^3$, and the working temperature and humidity ranges are − 10 to 60 ◦C and 0–99%, respectively. We will calibrate PA sensor measurements to ensure the quality control of $PM_{2.5}$ measurements following the approach developed by Lu (2021).[18] The detailed strategy of quality control is summarized in the Quality Assurance Statement (QAS).

We will also mobile monitoring campaign to enhance community-based exposure assessment in Aim 3 by providing high-resolution observation data for satellite calibration. Mobile monitoring is an evidenced approach that can effectively characterize fine-scale air quality distribution for community-based studies. Co-Investigator Dr. Wang has experience designing a mobile monitoring campaign to assess air pollution exposure in Beijing, China.[21] Dr. Wang and the research team will collect $PM_{2.5}$ and NO_2 monitoring data by driving a vehicle outfitted with an array of real-time commercial monitors (TSI DUSTTRAK 8533 and Aeroqual S500, 10s resolution) throughout the neighborhoods of the Buffalo's African-American community. We will ensure the prescribed mobile monitoring routes cover the most densely populated residential areas and those with high risk of ER visits. In addition to continuous driving, we will apply a fixed monitoring strategy to investigate exposure levels in neighborhoods of susceptible population including school districts, nursing homes, hospitals and areas close to highways by stopping the vehicle at each measurement location for 20 minutes. To obtain robust monitoring data for sensor replacement and exposure modeling, the monitoring campaign will last for 2 months in both summer and winter seasons within a year with each site and route being visited for at least 5 times on different days of a week. Temporal adjustments will be performed based on exposure data from the nearest AQS sites in order to collect highly resolved seasonal $PM_{2.5}$ and NO_2 measurements. The mapping data will then be used to identify high exposure spots in which the $PM_{2.5}$ and NO_2 exposures are above the median levels of the community and to improve exposure predictions as described in Aim 3.

Both the $PM_{2.5}$ measurement data collected at each monitoring site and mobile monitoring efforts will be automatically collected and stored at our secure server in the Center for Computational Research (CCR) of UB. Our research team will develop a website for this project where a map of real-time air quality will be shared among the study participants. Under the consensus of study participants who are willing to share the ambient air quality data collected at their residence, these highly localized and real-time air quality data can also be shared among the community members who did not participate in the data collection but are interested in air quality.

Aim 3. Determine community-specific air pollution exposures and detect air pollution hotspots

To predict the exposure concentrations of $PM_{2.5}$ for unmonitored locations, we will integrate PA sensor measurements with existing $PM_{2.5}$ observations from AQS, satellite-derived AOD, and auxiliary data using a statistical approach. Specifically, we will develop a land-use regression (LUR) model that is based on regression analysis that includes spatially-resolved predictor variables to model exposure concentrations.[22] Dr. Meng is an expert on LUR and has developed many LUR models for community-based studies in the US and Europe.[23, 24] He will be responsible for estimating $PM_{2.5}$ exposures for the study community.

In addition to $PM_{2.5}$, we will characterize NO_2 exposures and spatiotemporal hotspots in the Buffalo African-American community using satellite-observed NO_2. Nitrogen oxides ($NOx = NO_2 + NO$) is at the center stage of air pollution chemistry by modulating Ozone and secondary aerosol formation. We will use satellite observations of NO_2 to infer the distribution and emission of NOx, which is mainly from fossil fuel combustion. We will combine NO_2 data from the Tropospheric Monitoring Instrument (TROPOMI) instruments. TROPOMI started generating scientific data in 2018 and provides NO_2 observations[25] at high spatial resolution (the nadir TROPOMI pixel size is 7×3.5 km before August 2019 and 5.5×3.5 km). In the present study, we will use TROPOMI NO_2 observations oversampled to 250 m resolution[26], after its calibration with ground-based NO_2 observations. Detailed strategy for the calibration of TROPOMI NO_2 observations is discussed in the QAS document.

Based on the spatially and temporally resolved $PM_{2.5}$ estimates (i.e., hourly $PM_{2.5}$ exposure and daily NO_2 estimates at 250 m resolution), we will identify air pollution hotspots where higher levels of ambient air pollutants ($PM_{2.5}$ and NO_2) were observed at a specific time of day or a day of week, and assess the factors that may affect the concentrations of these pollutants. These factors include but are not limited to traffic volume from nearby major roads, proximity to railroads and RMP facilities, and position of traffic signals and street incline. Our research team has published two articles that demonstrate that TROPOMI resolves surface-level patterns in NO_2 inequalities with race, ethnicity, and income in Houston, Texas[4] and constrains the portion of NO_2 inequality caused by diesel truck traffic in 52 major U.S. cities.[5] Both analyses relied on the satellite data oversampling framework developed by Co-Investigator Dr. Sun to create spatially resolved maps of NO_2 vertical column densities for combination with census tract-scale demographic datasets.

Aim 4. Disseminate research findings to community residents

We will engage the community through our collaboration with the African-American Health Equity Task Force (AAHETF) and the Buffalo Center for Health Equity (BCHE) by providing a space for conversation and sharing research findings, including both the hotspot detection and the collected data. To achieve this goal, we will take two different strategies depending on the level of community members' willingness to participate in the study. For active members of community, we will use an interactive community forum to seek input on environmental health issues and concerns. Our research team will facilitate the forum by encouraging dialogue and enforce rules of interaction and communication by assisting with technical aid or transportations to meeting places. Our research team will also develop an alert system that will send an automatic message via a text when the ambient air quality is worsened beyond the EPA standard. This message will be, however, sent only to the community residents who signed up and who are interested in air quality in their neighborhoods.

For less active community members, we will give public presentations to share our findings on hotpots of each air pollutant and the peak of the time when the air quality is highly toxic. To ensure we disseminate our findings to the broader community, we will submit information for publication to *the Challenger*, a local newspaper broadly read by the African-American community. We will also develop a project website where the community members can check the air quality status and the real-time sensor measurements on the map.

In both the community forum and public presentations/dissemination, we will help community members to acquire scientific knowledge about environmental exposures in their neighborhoods that maybe used to inform policy and regulatory decisions.

2. Community Involvements

A. Community Partnerships: The proposed community-based air monitoring project will include a community-based participatory design to encourage community engagement in all phases of the research process, including obtaining input about the need for air quality improvement, discussion with community stakeholders about air pollution monitoring network design, placement of PA sensors outside their homes, sharing the research results (e.g., real-time information of ambient air quality, hotspot detection, and identification of potential sources of major ambient air pollutants). We will work closely with the AAHETF, the BCHE and other community-based organizations that are interested in air quality and community health to review all monitoring procedures, community participation, as well as analyses and interpretation.

Community engagement will be facilitated by the strong partnership with the community leader Pastor George F. Nicholas. Rev. Nicholas is a pastor of Lincoln Memorial United Methodist Church-Buffalo and a convener of the AAHETF, the BCHE, and the Greater Buffalo Racial Equity Roundtable. Both Pastor Nicholas and Co-Investigator Dr. Grinslade have been working with the African-American community in the east side of Buffalo on several projects. In the Reach Grant, which was supported from CDC under the Racial and Ethnic Approaches to Community Health program in years 2018-present, they are working to decrease tobacco use with emphasis in prohibiting smoking in apartments and employment, to promote the inclusion of fresh fruits and vegetables into corner stores in a community with vast food deserts, and to promote the uptake of Influenza and Covid vaccines through the use of pop-up and mobile clinics. An on-going community-based project, supported from a PICORI grant (The Mellowing Minds Study), aims to mitigate the effect of COVID on mental health in underserved African-American community residents in Buffalo with emphasis on the east side

B. Community Engagement: Specific details on the community engagement activities in the proposed project are the following: In the 'design' phase, our team will meet with *the project advisory committee*, consisting of community leaders (i.e., the pastor Nicholas) and other individuals from the BCHE and community-based grassroot organizations. In the meeting with community (leaders), we will identify the most vulnerable populations in the community and potential risk factors that the community is most concerned about, and develop recruitment strategies and effective forms of direct communication with community members. For example, our research team will participate in the annual community conference "Igniting Hope: Building a Just Community with a Culture of Health and Equity' (https://www.buffalohealthequity.org/) and other forms of community forums to recruit study participants, join the roundtable to discuss health disparities facing the Buffalo African-American communities, and collect concerns raised by community members that contribute to disparities in both environmental exposures and adverse health outcomes.

In the 'planning' phase, we will organize meetings at sites such as churches and community centers with Buffalo African-American community members who are potentially willing to participate in the proposed project by allowing our research team to install and access PA sensors outside their homes. We will explain and demonstrate the entire procedures how to install PA sensors, how the collected data will be shared (i.e., who has the ownership and how to distribute the information), and what will be the expected outcomes. The participants will review all proposed data collection and analyses plans prior to committing to the study, including the scheduling of research team's visits to their home for installation of sensors. The optimal sampling sites will be determined based on the analysis of spatial and temporal variation of air pollution at fine spatial scale, health impact assessments (i.e., ER visits for respiratory disease), and the community concerns.

In the 'performance' of the project, we will have regular meetings (i.e., three times a year) with study participants and other community organization groups to discuss the progress of the project in terms of data collection, mapping and visualization of collected data, and the retrospective health studies on the effects of short-term and long-term exposure to toxic air pollutants on respiratory disease. We will also show the spatial gradients of air quality based on air pollution exposure estimates (Aim 3). In addition, we will have training and education sessions how to interpret both the quantitative and qualitative air quality information (e.g., air quality index), and specific action items relevant to air quality warnings. Prior to sharing the knowledge from the proposed project, we will have the project advisory committee approve anything that is to be published from the research in terms of papers, reports, or presentations. Lastly, we will ensure the proposed project becomes sustainable by keeping in touch with the service providers and leaders in the community. Depending on the outcomes of the project, the research team will set about writing a proposal for an expansion of the project. This proposal will be submitted as a project under the R21 funding mechanism through the National Institute on Minority Health and Health Disparities (NIMHD).

3. Environmental Justice and Underserved Communities

The poor health and deteriorating socioeconomic conditions in Buffalo's African-American community were documented in the recent report, `*The harder we run*', by the BCHE (2021).[6] The report highlighted persistent problems that Buffalo's African-American community experienced over the last 31 years, including the racial residential segregation, staggering under-development, increasing poverty/unemployment, and poor health, along with recommendations to address these serious problems. One of the alarming findings was that community health has been deteriorating community health. The disparity in community health by racial and socioeconomic status was clearly shown in the COVID-19 positive rates at the beginning of the pandemic before vaccines were widely available. As shown in Figure 3 (top panel), the population adjusted COVID-19 rates of the Buffalo African-American community was twice as high than the region-wide rate in 2020. According to Pastor Nicholas, "These unjust indications show you something is systemically wrong. This is a crisis; this is not episodic. We are in a continued, ongoing health crisis."[27]

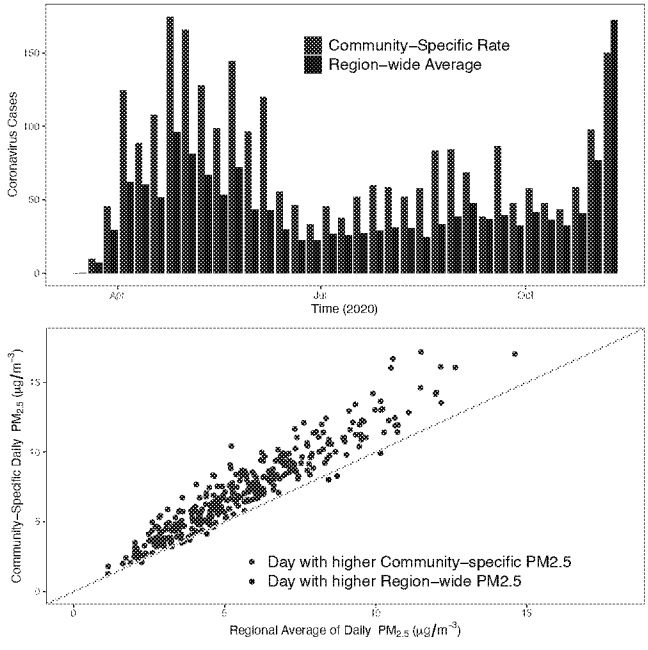

Figure 3 Comparison of Community-specific and Region-wide COVID19 risk (2020) on the top panel and daily $PM_{2.5}$ estimates (2016) at the bottome panel.

The report[6] also revealed the poor health among children in the community (e.g., high rates of asthma hospitalization). This is in line with the recent national study[11] where the children's asthma rate among low-income family is consistently increasing in comparison to that of high-income family in US. Our preliminary analysis of ER visits for asthma in Erie/Niagara counties between 2010 and 2016 yielded a similar conclusion where the community-specific risk of ER visits for asthma was four times higher than the region-wide average. As shown in Figure 2, the estimated risk for ER visits for

asthma formed a localized spatial hotspot within the Buffalo African-American community. The potential risk factors that might be associated with elevated risks in this community need further investigation with the spatially and temporally resolved $PM_{2.5}$ and NO_2 exposure estimates, as well as the proximity to other mobile/industrial emission sources. As a first step of investigating the potential associations, we compared Buffalo's African-American community-specific $PM_{2.5}$ concentration level versus the county-wide daily $PM_{2.5}$ concentration level each day in 2016. As summarized in the scatter plot in Figure 3 (bottom panel), the daily community-specific $PM_{2.5}$ exposure was higher than the region-wide average almost every single day except 9 days in 2016. Although our analysis was based on $PM_{2.5}$ exposure estimates obtained from a satellite-derived AOD prediction model,[28] higher $PM_{2.5}$ concentration of the community-specific exposure was clearly shown.

As shown in Figure 2 (marked as squares shaded by magenta color), current active EPA monitoring stations are located outside the Buffalo's African-American community neighborhoods and thus, accurate information on the spatially and temporally resolved air quality is yet unavailable. Hence, our primary goal is to *document* the spatial inequality in air pollution exposures of the underserved communities by quantifying daily exposure to multiple air pollutants in both retrospective and prospective studies. We will also *assess* the associations between air pollution exposure and adverse health outcomes at multiple spatial and temporal scales, i.e., hourly, daily exposure, cumulative exposures over year, within zip codes or census blocks (assess whether spatially unequal exposures result in disproportionate health effects when other known determinants of health are taken into account.). In addition, we will *identify* risk factors that are causing the disparate effects, i.e., proximity to major roads, a lack of green space (parks, trees), or hazard facilities (incinerators).

We expect that the identification of health effects may result in policy action aimed at promoting a more equitable sharing of the distribution of pollution and other environmental hazards or more diligent in the health surveillance of high-risk populations.

4. Environmental Results

A. Expected Outputs: We expect that the proposed project will yield multiple outputs, including: (1) development of an optimal air monitoring network; (2) deployment of portable low-cost sensors within the neighborhoods of Buffalo African-American community; (3) community-specific air pollution exposure assessment; and (4) regular meetings with community members (e.g., forum, annual conferences, community meetings). More specifically, we will assess temporally-resolved (hourly for $PM_{2.5}$ and daily for NO_2) air pollution exposure at fine spatial resolution (i.e., 250 m) within the Buffalo African-American community during the study period. These highly localized air pollution exposure estimates will be used for both epidemiological studies and hotspot detection to develop intervention strategies. During the study period, we will deploy PA sensors at optimal sampling sites over the two sampling campaigns to collect real-time $PM_{2.5}$ levels that complement the regulatory EPA $PM_{2.5}$ measurements provided by the AQS. Over the 3 years, a total of 60 monitoring sites will provide real-time $PM_{2.5}$ measurements. These real-time measurements of $PM_{2.5}$ levels will be readily available for community members through online access. These data will be shared among the community members and automatic text messages/emails will be sent when the extreme $PM_{2.5}$ levels are detected to the community members who signed up for the information share. Lastly, we will participate in annual conferences and organize three community meetings per year (specifically focused on recruitment, providing a mid-term report, and providing a final report) to elevate the awareness of air pollution exposure, encourage community conversations about environmental disparity and health concerns, and lastly keep the community informed about the environmental hazard, air pollution risk, and mitigation strategies.

B. Expected Outcomes: At various stages of the proposed study, we will increase community awareness of air pollution exposure and consequent health risks, including hospital admission for respiratory diseases. Through multiple meetings with community members, our research team will learn about community member perceptions of environmental health concerns and gain insight into the major sources of air pollution. The optimal monitoring site selection for PA sensor network will account for the community health concerns and known risk factors.

Based on the real-time air quality data, we will also keep the community members informed about the local air quality regardless of their participation on the data collection. First, we will create a website that community residents can refer to prior to making decisions to adjust their activities during increased levels of air pollutants.

For any member of community who is interested in real-time information about ambient air quality, we will share the collected community-specific air quality data via either a text or email. In addition, we will present our findings in the annual conferences with community. In community meetings organized by the research team, we will share hotspot detection of instances with extremely high $PM_{2.5}$ concentrations. Our research findings will be used to identify the major sources of air pollution in local neighborhoods and further develop control and reduction solutions.

C. Performance Measures and Plan: The research team will meet with community members 3 times per sampling campaign, specifically prior to recruitment, during a mid-report presentation, and during a post-meeting. Our research team will document all meetings with community leaders and residents, during which we expect that we will learn about their environmental health concerns and common issues. Meeting notes will be made available as an appendix of quarterly reports and the final report. The number of community residents who signed up for the study will be a quantifiable metric for community engagement of this project.

In addition, we expect that we will make two purchases of low-cost air sensors (N = 30) during the second phase of Year 1 (April 2023 – Jun 2023) and Year 2 (April 2024 – Jun 2024). In both cases, we will conduct a pilot test to assess any technical issues on the operation of sensors at community residents. The second purchase of sensors (N = 5) will depend on the condition of air pollution sensors that are recollected after the sampling campaign. If the initial sensors (a total of 30) are intact and reusable, we will cancel or reduce the number of second purchase of sensors. Dr. Yoo and the Project Coordinator will contact the vendor and manage the procurements.

We will store all the data collected on our secure web server (i.e., CCR at UB), and hourly and daily community-specific air pollution exposures will be shared with community residents. The collected air quality data can also be shared with community members who might be interested in the calibrated $PM_{2.5}$ concentration levels. The performance of portable air sensors can be quantified by the number of missing values, which we will be included in both quarterly progress reports and the final report.

D. Timeline and Milestones: In Year 1, we will form a complete research team, including a Project Coordinator and research assistants and begin data collection at optimal sampling sites (N = 30) selected by applying the spatial sampling strategy (Aim 1). We will plan, recruit, and engage community members through community meetings that consist of the project inaugural meeting with a project advisory committee, followed by meetings with community residents for study participant recruitment and study orientation (Aim 4). The optimal sampling site selection also calls for retrospective epidemiological studies with air quality data for both $PM_{2.5}$ and NO_2 concentration levels, and thus our research team will collect existing data and compile them.

In Year 2, we will finish the first wave of real-time air quality data collection and begin the second save at the set of newly selected optimal sampling sites (N = 30). The optimal spatial sampling algorithm will account for the spatial variation of $PM_{2.5}$ measurement data obtained from both PA sensors and mobile sampling, as well as community inputs. We will calibrate raw $PM_{2.5}$ measurements and synthesize the data with meteorological, land use, and traffic variables for exposure estimation. Meanwhile, we will communicate with community members through the public presentation, annual conference attendance, and data sharing.

In Year 3, we will finalize the data collection and pool all the data together to estimate the community-specific air pollution exposure, which will enable us to identify air pollution hotspots and assess key factors that may affect the concentrations of $PM_{2.5}$ and NO_2. We will share the research findings with community through public presentations and writing reports, newspaper articles, and manuscript publications.

Funding period	**Study setup, Staff hiring, Training**	**Community Meetings**	**Optimal Sampling Design**	**Sensor Deployment & Calibration**	**Data Compiling**	**Exposure Model Development**	**Manuscript & Report writing**
YEAR 1							
Nov 22- Mar 23	X	X			X		
Apr 23 – Jun 23		X	X				X
Jul 23 – Oct 23		X		X (N = 30)	X		X
YEAR 2							
Nov 23- Mar 24		X		X	X	X	

Apr 24 – Jun 24		X	X	X	X	X	X
Jul 24 – Oct 24		X		X (N = 30)	X		X
YEAR 3							
Nov 24- Mar 25		X		X	X		
Apr 25 – Jun 25		X		X	X	X	X
Jul 25 – Oct 25		X				X	X

5. Quality Assurance Statement

Please see the mandatory attachment.

6. Programmatic Capability and Past Performance

A. Past Performance: PI Yoo completed a project under the title of "A Three-population three-scale social network model to assess disease dispersion", funded from the National Institute of General Medical Sciences of the National Institutes of Health R01GM108731 on Mar. 10, 2015 - Feb. 28, 2020. As a Co-investigator, she engaged a survey design, hiring staff (Project Coordinator and Research Assistants), recruitment of study participants (a total of 3,713 residents of Erie/Niagara Counties) survey data collection, as well as manuscript writing and presentation of the results at professional conferences. In a study that is closely related to the proposed project, Dr. Yoo led a project, entitled "Modeling ambient air pollution using optimal sensor placement and multiscale spatiotemporal data fusion", funded from Research and Education in Energy, Environment and Water (RENEW) Standard Seed Grants at UB. She successfully implemented the research on air monitoring data collection strategy based on low-cost sensor deployment and developed a data fusion framework to predict air quality using recent technological advancements in sensor developments and sensor network design. Co-I Sun has significant experience in both leading and participating in research teams involving satellite observations. He is the PI of NASA funded project "Observational Data-driven Surface concentrations Derived from Satellite Columns and Aircraft Profiles", Co-I of NASA funded project "The Long-Term and Consistent Earth System Data Records of H2CO, CHOCHO and H2O from Multi-Satellite UV/Visible Spectra", Co-PI of DOE funded project "The 'System of Systems' Solutions for Commercial Field-Level Quantification of Soil Organic Carbon and Nitrous Oxide Emission for Scalable Applications (SYMFONI)", and a scientific partner of the MethaneSAT project. Co-I Wang is leading a project entitled "Air Pollution, Coronary Events and Atherosclerotic Progression in a Susceptible Population" funded by NIH/NIEHS R01ES031986 from July 2021 to April 2026. As a PI of the project, he is leading a mobile monitoring campaign in local area including study design, monitoring fieldwork, and data analyses. The knowledge he gained from the project will be beneficial for the proposed study to design and conduct mobile monitoring campaign in Buffalo area.

B. Reporting Requirements: PI Yoo completed the required annual reports and final reports to NIH and the RENEW institution successfully. The results from R01GM108731 were published as 7 journal articles and the RENEW project produced 4 publications. Co-I Sun led and completed a project titled "A Satellite Data-Driven Framework to Quantify Sources and Lifetimes of Atmospheric Pollutants and Their Responses to the COVID-19 Pandemic" funded by NASA Rapid Response and Novel Research in Earth Science (RRNES) program (07/07/2020 – 07/06/2021). Under this funding support, Dr. Sun advised two master students, presented the results in the American Geophysical Union annual conference, and published a paper titled "A Satellite Data-Driven Framework to Rapidly Quantify Air Basin-Scale NOx Emission and Its Application to the Po Valley during the COVID-19 Pandemic" on the journal Atmospheric Chemistry and Physics. Co-I Wang has successfully completed 1st year annual report to NIH.

C. Staff Expertise: PI Yoo will bring over 8 years of research experience in large database management systems, such as the statewide planning and research cooperative systems (SPARCs), which includes ER visits. She will be also responsible for sampling design and data collection (Aim 1 and 2), which involves the combined environmental exposures on respiratory health outcomes. PI Yoo will work closely with two Co-Is Wang and Sun to estimate hourly and daily environmental exposure (Aim 3) within the Buffalo African-American Community neighborhoods. Co-I Dr. Grinslade have worked with the Black African-American Community for CDC-funded the Research Grant project, where she worked with pastor Nicholas and other

grassroot organization leaders as well as community residents. She will link our research team with the community through her established connection (Aim 4). Both Drs. Wang and Kang have substantial expertise in air pollution modeling with their background in epidemiology and civil engineering, and they will participate in a part of Aim 2 and 3. With Dr. Yoo, the project coordinator, Dr. Grinslade and a doctoral-level GRA at Geography also will work closely with the community members to install, maintain, and collect the air quality data. All members of this team are highly productive and widely recognized investigators in their respective areas, and bring unique and critical expertise to the project.

7. Budget

Personnel: *There is a 2% increase after Year 1 for all personnel for cost-of-living adjustments.

Position/Title	Annual Salary	% Time assigned to Project	Year 1	Year 2*	Year 3*	Total
PI Eun-Hye Yoo	$30,836	5%	$1,542	$1,573	$1,604	$4,719
Co-I Kang Sun	$35,283	3%	$1,176	$1,200	$1,224	$3,600
Co-I Margaret Grinslade	$154,869	1%	$1,291	$1,316	$1,343	$3,950
Co-I Meng Wang	$107,689	1%	$897	$915	$934	$2,746
Project Coordinator	$50,000	50%	$25,000	$25,000	$26,010	
Graduate student	$26,520	100% Y1-2, 25%Y3	$26,520	$27,050	$6,898	$60,468
Graduate student	$26,520	25% Y1-3	$6,630	$6,763	$6,898	$20,291
Graduate student	$26,520	25% Y3	$0	$0	$6,898	$6,898
Total			**$63,056**	**$64,317**	**$51,809**	**$179,182**

Fringe Benefit: Fringe benefit rates are based on the applicable state and federally negotiated rates.

Position/Title	Base Fringe % Rate	Cost			Total
		Year 1	Year 2*	Year 3*	
PI Eun-Hye Yoo Co-I Kang Sun	14% (Y1); 14%: (Y2); 14.5% (Y3)	$381	$388	$410	$1,179
Co-I Margaret Grinslade Co-I Meng Wang	63.72% (Y1); 62.40%: (Y2); 63.39% (Y3)	$1,394	$1,392	$1,443	$4,229
Project Coordinator	40% (Y1); 41%: (Y2); 50.42% (Y3)	$10,000	$10,583	$10,924	$31,507
Graduate student	13% (Y1); 13%: (Y2); 14.5% (Y3)	$4,310	$4,396	$3,001	$11,707
Total		**$16,085**	**$16,759**	**$15,778**	**$48,622**

Travel: Community site visit will occur for the installation and maintenance of low-cost sensors. This will also include partial support for the transportation fee association with mobile air monitoring efforts. The location of international conferences (e.g., International Society for Environmental Epidemiology) varies each year.

Purpose of Travel	**Location**	**Item**	**Computation**	**Cost**
EPA Progress Review	Washington DC	Lodging	1 people x $172 per night x 2 nights	$344
		Airfare	1 people x $500 round trip	$500
		Per Diem	1 people x $79 per day x 2 days	$158
		Ground Transport.	1 people * $100 round trip	$100
Community site visit & mobile monitoring	Buffalo, NY		50 miles/week x 52 weeks	$1,456
Subtotal per year				$2,558
International Conference in Year 3	TBA	Registration	2 people x $600	$1,200
		Lodging	2 people x $252 per night x 4 nights	$2,016
		Airfare	2 people x $1000 round trip	$2,000
		Per Diem	2 people x $79 per day x 4 days	$632
		Ground Transportat.	2 people * $101 round trip	$202
Subtotal				$6,050
Total travel				**$13,724**

Supplies: We have requested fund to purchase a computer for the PI and two Co-Is. The computer will be used only for this project. Initially 30 PA-II-SD sensors will be procured and its replacement may occur in the Year 2 and 3 depending on the condition of the sensors.

Items	**Year 1**	**Year 2**	**Year 3**	**Total**
3 Computer ($2,500 per computer)	$7,500	$0	$0	$7,500
PurpleAir $PM_{2.5}$ monitors ($276 per unit)	$8,280	$1,380	$1,380	$11,040
Outreach Materials and Supplies	$833	$833	$833	$2,499
Total	$16,613	$2,213	$2,213	**$2,000**

Other: We have requested funds to cover UB's Center for Computational Research service fee, as well as publication costs associated with submitting manuscripts for dissemination. We also have included funds for tuition for the graduate student. We have requested for the consultant cost for the community organizer (Pastor Nicholas). The community participation is requested to compensate their time and efforts, as well as the use of their utility (electricity) and property for sensor installation and maintenance. We also asked for the community meeting logistics to cover the transportation, child care cost, and meals (if it's overlapped with meal time).

Items	**Year 1**	**Year 2**	**Year 3**	**Total**
Participant incentives ($100 per household)	$2,000	$2,000	$2,000	$6,000
Community Meeting Logistics (3 meetings per year)	$3,000	$3,000	$3,000	$9,000
Consultant Cost ($50 per hour)	$500	$500	$500	$1,500
Annual resource fee for UB Center for Computational Research	$2,000	$2,000	$2,000	$6,000
Publication	$2,000	$2,000	$2,000	$6,000
Out of State Tuition 9 Credit Hours/Semester $982 (Y1); $1,002 (Y2); $1,022 (Y3)	$17,676	$18,036	$0	$35,712
Total Other Expenses				**$47,712**

Indirect Costs: The indirect costs are calculated at the UB predetermined Facilities and Administrative (F&A) cost rate of 59.5% MTDC per DHHS agreement dated 03/25/22.

Items	Year 1	Year 2	Year 3	Total
Indirect Costs	$64,148	$56,731	$52,305	$173,184

Total Project Cost: The sum of both Direct and Indirect cost per year.

Items	Year 1	Year 2	Year 3	Total
Total Project Cost	$189,636	$170,114	$140,213	$499,963

Both PI Yoo and the Project Coordinator will be primarily responsible for the efficient and timely expenditure of the EPA funds. To ensure the successful completion of the project, they will take the EPA Grant management and other relevant training courses in Year 1. In addition, both PI Yoo and the Project Coordinator will set up a Grant Project File and document every detail of the project and its expense. This will include the procurement of the low-cost sensors, which will be purchased in Year 1. We will limit the number of sensors to 30 in Year 1 and will procure additional sensors in Year 2 and 3 only if some sensors need to be replaced after our careful examination. We will retain all the documents containing the correspondence with the vendor and EPA throughout the project period. Meanwhile, we will effectively use the funding to encourage the community participation from the Buffalo African-American community residents by covering registration fees for community members to attend conference (or project-related workshops) and provide transportation, meals (if it's overlapped with their meal time), and child care cost during their attendance of the meetings. Every details of transactions and expenses associated with these various activities will be submitted in the quarterly progress reports and the final report by carefully following the best practice guide of EPA assistance agreement throughout the project.

Manifest for Grant Application # GRANT13580122

Grant Application XML file (total 1):

1. GrantApplication.xml. (size 23826 bytes)

Forms Included in Zip File(total 6):

1. Form ProjectNarrativeAttachments_1_2-V1.2.pdf (size 16119 bytes)

2. Form SF424_3_0-V3.0.pdf (size 24139 bytes)

3. Form SF424A-V1.0.pdf (size 22801 bytes)

4. Form EPA4700_4_3_0-V3.0.pdf (size 22635 bytes)

5. Form OtherNarrativeAttachments_1_2-V1.2.pdf (size 15890 bytes)

6. Form EPA_KeyContacts_2_0-V2.0.pdf (size 37334 bytes)

Attachments Included in Zip File (total 5):

1. ProjectNarrativeAttachments_1_2 ProjectNarrativeAttachments_1_2-Attachments-1237-project narrative 0322.pdf application/pdf (size 1517843 bytes)

2. ProjectNarrativeAttachments_1_2 ProjectNarrativeAttachments_1_2-Attachments-1238-bibliography 0322.pdf application/pdf (size 87966 bytes)

3. OtherNarrativeAttachments_1_2 OtherNarrativeAttachments_1_2-Attachments-1235-CV_keypersonnels.pdf application/pdf (size 916161 bytes)

4. OtherNarrativeAttachments_1_2 OtherNarrativeAttachments_1_2-Attachments-1234-QAS 0322.pdf application/pdf (size 121486 bytes)

5. OtherNarrativeAttachments_1_2 OtherNarrativeAttachments_1_2-Attachments-1236-Consultant Letter of Support for Yoo 030722.pdf application/pdf (size 103076 bytes)